PARIS INTERNATIONAL EXHIBITION, 1900.

Illustrated Handbook

OF

WESTERN AUSTRALIA.

Issued by the W.A. Royal Commission.

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EDITOR'S NOTE.

IN issuing this illustrated Handbook of Western Australia, the Royal Commission appointed by Parliament to secure the adequate representation of the Colony at the Paris Exhibition of 1900 desires to place before the outer world a more perfect knowledge of the immense natural resources, together with the industrial and social developments of this young country which, but lately emerged from the comparative obscurity of the past, now bids fair, in the light of present progress, to rank as one of the most noble possessions of the British Empire. The various resources and industries that are now being opened up and prosecuted, the great latent possibilities awaiting only the magic touch of human enterprise to respond with a golden harvest, the adaptability of soil and climate for the home and health seeker, all these are briefly touched upon. Thus, the reader of this work may obtain at least some reliable insight into the many advantages the Colony of Western Australia offers to the capitalist in search of profitable investment, to the worker who finds his sphere of utility circumscribed in the crowded marts of the old world, to the traveller whose jaded senses require the stimulus of fresh scenes 'neath sunny skies, and to all those looking for a home in a genial climate and a new country under the freedom of the British flag.

The articles herein are from the pens of those competent to speak of the various subjects treated of, and care has been taken in all cases that the information supplied may be confidently relied upon.

The Commissioners have pleasure in acknowledging the very great assistance they have received from the gentlemen whose names appear as writers of the various articles in the Handbook, from the heads of the various Government Departments who have supplied the latest official information, from the Registrar-General (Mr. Malcolm A. C. Fraser) and his staff, from the Government Printer (Mr. R. Pether), and from the Government Photo-lithographer (Mr. H. J. Pether). The illustrations that give point to the literary matter are reproduced from photographs taken by Messrs. Greenham & Evans, of Perth, W.A.

GEORGE AYTOUN,

Secretary,

Royal Commission Paris International Exhibition, 1900.

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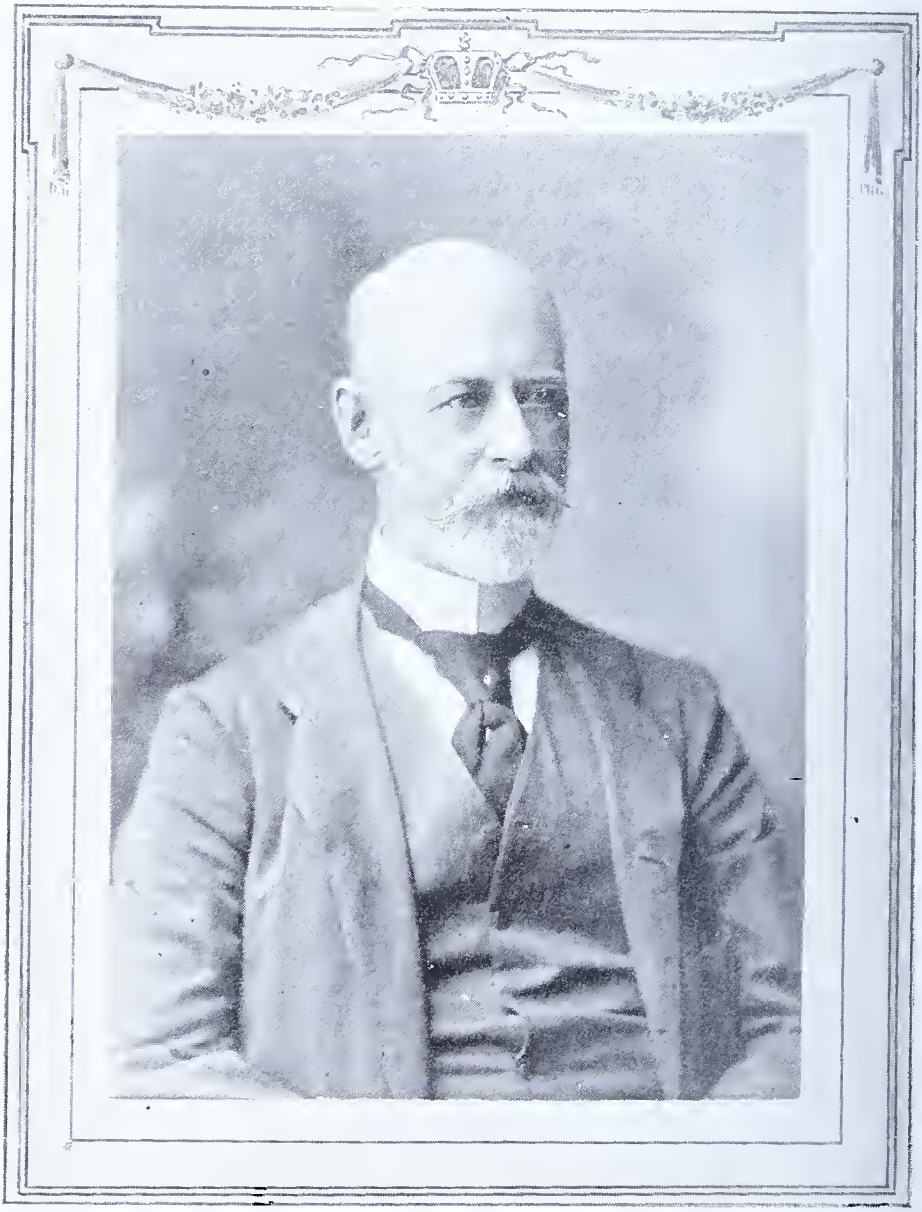


H. E. Lt. Col. Sir Gerard Smith, K.C.M.G.,
Governor of Western Australia.

WESTERN AUSTRALIA.

(By George Hope.)

AUSTRALIA, the fifth continent of the world, embraces an area of over three million square miles, and of this vast territory one-third, or 975,920 square miles, is embraced within the boundaries of the Colony of Western Australia. With a length from North to South of 1,480 miles, an extreme breadth from West to East of 1,000 miles, and a length of coast line of 5,200 miles, the area of Western Australia in acres reaches a total of 624,588,800. On three sides it is bounded by water, the Northern and Western shores being washed by the Indian Ocean, and the Southern coast by the great Southern Ocean. Harbours, though not numerous, exist in sufficient number to meet the utmost limits of future expansion. With a climate unsurpassed in the world, varying from the excessive heat of latitudes just below the equator to the temperate and cool atmosphere of its Southern borders; with every variety of humidity, from its coast line with its abundant rains, to the elevated and dry plateaux of its vast Eastern stretches along the boundary line of South Australia, the Colony holds within its confines a divergency of natural products, of limitless potentialities of development that await only the touch of human enterprise to convert Nature's raw materials, provided with lavish hand, into those tangible assets that spell national wealth and commercial prosperity. Clothed throughout its Southern reaches with a wealth of magnificent forest timber, from which are drawn supplies of native hardwoods to fill the world's markets; blessed with great plains of succulent grass in the North, on which browse herds of cattle and flocks of sheep; its ironstone hills, the ideal locality for vigneron and orchardist: Western Australia, in addition, boasts the possession of mineral wealth; of gold, silver, copper, coal, even gems, in belts stretching for hundreds of miles, and as yet but barely tested, and holds a record as an exporter of bullion that in a short decade has placed her far ahead of her sister colonies and given her the premier position in Australasia. Some account of her past, with the growth achieved and development accomplished to date, will enable the reader the better to gauge the possibilities for her advancement in the years to come.

The actual discovery of our vast island continent lies hidden in a veil of mystery. Traditions of a Great South Land, originating with the ancients more in the unsubstantial spirit of prophecy than in the possibility of recorded fact, seem to have been in existence as far back as history traces, and it was doubtless these, crystallised into firm conviction by rumours from the Orient, that, in trading with the East India Islands, the Chinese navigators in the early centuries of the Christian era had actually sighted the *Terra Australis incognita*, that inspired the mariners of Europe to strike out into the unknown oceans below the torrid zone with hope of tangible results. Fired by the success of Columbus and the golden trophies of Hernando Cortez from the new world, Portuguese, Dutch, Spanish, French, and English maritime enterprise drew to its aid the boldest, hardiest spirits of the age, and the earliest years of the sixteenth century saw, from the harbours of the old world, pour forth a motley fleet of adventurers, half buccaneer, half trader, to scour the seas in search of new lands and boundless treasure.

Gonneville, a Frenchman, in 1503, and Magellan, the Portuguese, in 1520, both claim to have sighted the Southern Continent. Old charts existing to-day show the name Magellanica scrolled across the shadowy reaches of a long coastline South of Java. Half-a-dozen early Portuguese maps confirm to that nation the actual but futile honour of first discovery; and no doubt Menezes, in 1527, touched at and named the Abrolhos Islands, off the coast of West Australia. *Littera scripta manet*, and there is small reason to withhold from Menezes the credit of a Columbus, at least as regards that portion of the Great South Land to which this article is devoted. In 1598, Houtman, the projector of the Dutch East India Company, gave his name to the Abrolhos Islands off Geraldton, and here, in 1629, Pelsart, in the ship "Batavia," blown by adverse gales from his course to the new Dutch Colonies, suffered shipwreck. The story of the mutiny of the crew, with its tale of massacre and bloodshed; the brief reign of the upstart Cornelis as king of the buccaneers, the retribution, when rescue and capture disclosed the fate of the murdered voyagers; all these are preserved in an old Dutch tome, dated 1647, and give a fascinating insight into one of the first recorded pages of Western Australian history. Meanwhile, the Dutch, with the spirit of a nation fresh in possession of their newly won independence, wrote their names far and wide on cape, and headland, on bays, islands, and territories in the New World below the equator, which their enterprise was rescuing from the ages of oblivion.

In 1616 Dirk Hartog, of Amsterdam, made Sharks Bay and named Doore Island after his pilot, and another Island after himself. In 1617 Zaachen sailed along the North coast and placed the name of his ship, the "Arnheim," on the territory. In July 1619, Jean Van Edel discovered and named the Edel's Land of all old charts, extending from Sharks Bay Southwards to Cape Leschenault. Cape Leeuwin (the Lioness) was first seen from the ship of that name in 1622, the appellation covering the adjoining land up to near the Swan River.

So far, the tortuous extent of our Western coastline had been added to the maritime charts of the old navigators, the turning point Eastwards was still a mystery till the "Gulde Zeepard," voyaging to Japan, rounded the corner of *Terra Australis* in 1627, and examined the coast for 1,000 miles along the Bight, the coast receiving the name of Nuyt's Land after either the commander or chief passenger on board.

In the following year DeWitt named DeWitt's Land between Champion Bay and Sharks Bay, and the North coastline was left to the navigator Tasman, discoverer of Van Dieman's land, now known as Tasmania, to be carefully mapped on more than one visit after his first voyage in 1642. In 1665 the Dutch gave to the whole Continent the name of New Holland, marking thus their priority of claim to their newly-acquired territory and placing the seal of possession upon the fifth continent of the world, a vast tract of over three million square miles, measuring 2,500 miles from East to West, and 1,950 at its greatest breadth; after America, the greatest heritage of the Anglo-Saxon race, the brightest jewel in the Imperial diadem of the British Crown. *Terra Australis incognita*, under the title of New Holland, was now included within the line of demarcation of the Dutch East India Company's lands. The reports of the early navigators were anything but favourable to the new country. Almost every one of their records speaks of sand, treacherous blacks, absence of water, the plague of flies and general absence of those essential characteristics which go to make up the intrinsic value of colonial possessions. The fame of discovery, the greed of empire, the lust for gold, had in this case hardly repaid the efforts involved in their acquirement, and, with the wane of the Dutch maritime supremacy, Australia lapsed for a time into comparative oblivion once more. The fame of discovery proved a barren honour to Portugal, whose pre-eminence in the Orient soon waned in the face of Spanish conquest and the baneful influence of the Inquisition. The greed for empire was eventually a futile blessing to the hardy Dutch, with the adverse force of Cromwell, Blake, and the rising power of England's naval might and rivalry. The greed for gold has, however, in later years repaid Britain a thousandfold as incidental to the spread of civilisation under her proud flag.

Hitherto England had played no part in Australian history, but it was given to the famous buccaneer William Dampier, freebooter, gentleman rover, pioneer of commerce and conquest, to be the first Englishman to set foot on Australian soil. Quarrelling with his brother pirates, Dampier left Mindanao, and steering South in the "Cygnet," reached New Holland in January, 1688, and anchored in King's Sound, in Western Australia, not far from where the town of Derby now stands in the Kimberley Division.

In December, 1696, Vlaming, a Dutch navigator, anchored off Rottnest Island, discovering and naming the Swan River, on the surface of which the royal black swan, hitherto an unknown species, disported its feathered beauties in large flocks unmolested. The

river, on whose banks Perth and Fremantle now stand inviting the commerce of the world, was explored and charted. Rottnest was so called on account of the quantities of the nests of rats (wallabies) found there: And thus to Vlaming, scion of the race to whom our soil first owed allegiance, belongs the honour of navigating the first ship into what is now the port of Fremantle.

Dampier had meanwhile returned to England and published the first authentic book printed in English dealing with Australia. To such an extent was interest raised that H.M.S. "Roebuck" was equipped and despatched in 1698 in charge of the ex-buccaneer, to obtain more definite information as to the potentialities of New Holland.

In August, 1699, anchorage was obtained in a sound named by Dampier Sharks Bay. Nickol Bay and Cossack were explored, and large stretches of the coast line delineated. Returning home once more, Dampier issued his report—an unfavourable one, full of references to barren coasts and half-starved aboriginals, of fruitless search for water, and of dreary sand plains, stifling at once public and official interest, and setting back, unwittingly, the settlement of the Island Continent for almost three-quarters of a century.

The year 1770 ushers in a distinct epoch in Australian history, for it was then that Captain Cook, who might almost be called the father of the Imperial possessions in the South Seas, first sighted Australia at Cape Everard, in Gippsland, Victoria. Sailing along the East coast, he discovered Botany Bay, and, hoisting the British flag, took formal possession of the country. To the navigators and explorers of the Eastern portion of Australia, Cook, McCluer, Bligh, Bass, Furneaux, and others who planted the germs of British supremacy under the Southern Cross, the scope of this article does not extend. The next visitor of note to stamp the topography of Western Australia with British appellations was the explorer Vancouver, one of Cook's former officers, who, in 1791, entered King George the Third Sound, and named it after his sovereign. It is one of the most beautiful harbours in the world, with a climate unsurpassed on either side of the equator; on its bosom could float the combined navies of Europe, and it offers, from a strategical standpoint of national defence, the same position as regards the rest of the continent that Esquimault, in Vancouver's Island, does to the British colonies in the Northern Pacific.

At the close of 1792 the French ships "Recherche" and "Esperance," under command of Rear Admiral D'Entrecasteaux, arrived off our South-West coast in a profitless search for the romantic but ill-starred La Perouse, the French navigator, whose fate was shrouded in mystery. The coast was carefully explored, the expedition being responsible for much of the Gallic nomenclature figuring on our maps. Flinders and Bass united the chain of exploration from East and West in 1798, Murray following in 1802, while Flinders, in the same year, in the "Investigator," visited King George's Sound and the South coast, naming Fowler's Bay at the Western limit of South Australia. To Flinders we owe our present name Australia, for while Cook had named New South

Wales for the East, the rest of the continent was still known as New Holland, or by some *Terra Australis*. Flinders, having for the first time circumnavigated the entire continent, took possession of the whole for the British Crown. After passing six years in a French prison, Flinders returned to England and died at the early age of 40. Embodying the noblest qualities that have assured to Britain the supremacy of the seas, examples of pluck, tenacity, and dauntless resolve, the names of Dampier, Cook, and Flinders will live while history exists.

In 1802 another French expedition was fitted out to search for relics of La Perouse, or as some say, to claim for France the Southern coast of Australia. It consisted of the sloops "Geographe," "Naturaliste," and "Casuarina" and covered a long length of our coast line. Names were awarded to many of the chief features of the country visited. The Swan River was carefully explored, the Heirrison Islets, above Perth, being called after an officer. The Vasse was also named. Flinders, however, claimed priority of possession as regards the South coast, his claim being conceded on his release from a French jail, and the publishing of his travels.

The Northern coasts of Western Australia were surveyed by Captain King 1818 to 1824, his work being supplemented by Wickham and Stokes in the "Beagle," between 1837 and 1843, it being still thought possible that an opening along the coast would be found whereby access to the interior of the continent and its navigation should be accomplished.

The year 1826 marks a new epoch in the history of Western Australia. Hitherto discovery and exploration along the coast had marked the extent of European enterprise. Settlement was now to supersede vague conjecture in proving the value of the Western portion of the new continent. At this time the French had three ships cruising in these waters. Governor Darling, of New South Wales, suspected a contemplated annexation, and, to place beyond all doubt the British title to that part of New Holland still unsettled, despatched Major Lockyer with a portion of the 39th Regiment and some convicts, a party of 75 all told, to King George's Sound. On December 25th, 1825, the British flag was hoisted where the town of Albany now stands, and the act of possession consummated.

The settlement, isolated and small, was a failure, and Captain James Stirling in H.M.S. "Success" was despatched from Sydney in 1827 to examine the Swan River, with a view to settlement under more favourable conditions. The river was explored till fallen timber barred the stream, friendly relations were established with the natives, and an ascent of the Darling Range was made. The Canning River, hitherto called the Moreau by the French, was examined. Returning to Sydney in April, 1827, a report favourable, even sanguine, was presented to Governor Darling, whose subsequent representations to the Home Government largely influenced the authorities in their action in regard to the establishment of the new Colony.

To private enterprise, however, more than anything else is the founding of the Swan River Settlement, as for years it was entitled, due. True, the Government lent every aid, but to a party of wealthy and influential gentlemen, enthusiastic in that spirit for colonisation so virile a characteristic of the British race, and encouraged by the glowing reports of Captain Stirling, Captain Gilbert, and Mr. Fraser, the botanist, must credit be given for creating the nucleus of our present colonial well being.

In 1828 an association was formed, with Captain Stirling and Mr. Thomas Peel as leading spirits, and negotiations opened with the Government for introducing settlers in return for extensive grants of land. As finally arranged, the Government proclaimed the Colony of Western Australia and described its limits in the commission to its first Governor or Superintendent, to which office Captain Stirling was appointed, together with a staff of officials to aid him. To Mr. Peel was granted a quarter million acres, and grants of land were offered to settlers in return for capital invested, for stock and implements of productive industry introduced. In brief, the Government contributed its quota in land, not being, at the time, willing to spare much cash from a depleted national treasury, while individual energy supplied the money, brains, and muscle to carry the project to a successful issue.

Meanwhile Captain Fremantle, of H.M.S. "Challenger," to protect British interests, arrived off the port that now bears his name, and landing on May 2nd, 1829, hoisted the British flag and took possession formally, for his sovereign, of all that part of New Holland outside of New South Wales.

On June 2nd, 1829, the transport "Parmelia" arrived with Governor Stirling and a party of settlers, 69 in all. On the 8th H.M.S. "Sulphur" dropped anchor bringing troops. On June 17th was issued the first proclamation and appointment of officers on the landing of the forces. On August 12th the site of the capital, Perth, was chosen, and the city founded. Fremantle was also selected as a townsite, on the coast, in the interests of the shipping. In September the first assignment of lands on the Swan was made. In December, Mr. Peel arrived with 170 immigrants and stores. Ships to the number of 17 arrived up to December 31st, 1829, bringing, as far as can be ascertained, 1,767 persons, 101 horses, 583 cattle, 7,981 sheep, with pigs, goats, poultry, and some dogs.

And thus, six years before the founding of Melbourne by Batman and Fawkner, were our Western capital and our principal port laid out, the existence of the Colony commenced, and the usual hardships and privations incidental to the struggle with Nature in all new countries were undergone with varying vicissitudes by those sturdy pioneers who had left the amenities of civilisation manfully behind them to carve out homes in the virgin bush at the other side of the world.

In the following year, 1830, there arrived 39 ships bringing 1,125 passengers and leaving cargo valued at £144,177. Lands were assigned on the Helena and Canning rivers, while settlements

were formed at Port Leschenault and at Augusta in the extreme South. The Darling Range was crossed and the Avon river and York district discovered by Ensign Dale, of the 63rd regiment. In this year the natives began to be troublesome, and the first blood was shed by their unprovoked murder of Mr. McKenzie, on the Murray River.

A man named Entwistle was also barbarously murdered by the natives Yagan and Migegooroo, Mr. Phillips and Ensign Dale were wounded, and a great deal of breeding stock destroyed. Murders and outrages continued frequently. In 1833 Gaze, a settler at the Canning, was killed by Yagan, 200 pigs were driven away, and a soldier's wife was slain. A soldier was speared at Clarence; a white woman was assaulted by Yagan, and two men were killed at Bull's Creek by the same notorious chieftains, who appeared to have equalled Sitting Bull, of the Sioux, or Geronimo, the infamous Apache desperado. Migegooroo was taken and shot. Next year a soldier was killed by natives in the Barracks at the Upper Swan. Mr. Bland's cart was attacked on the York road, and Mr. Souper speared. An attack at Greenmount had been previously made on another cart, when Beecham was killed and Chipper severely wounded. Budge was slain at the Murray, and the soldiers were compelled to change their station for one of greater security. Many settlers thought of abandoning that part of the country after Nesbitt and Barron had been treacherously attacked in the same locality. Nesbitt was put to a most shocking death, Barron barely escaping with three spears sticking in his body, while Mr. Layman was killed at the Vasse. Captain, now Sir James Stirling, with a few gentlemen and five police, had a pitched battle with the blacks on the Murray. Three of the police were unhorsed by the first volley of spears, but were rescued by opening fire. Ten natives were shot, and Captain Ellis received a spear wound in the temple, from which he died about a fortnight later. The lesson, however, had a salutary effect and cowed the offenders.

In 1837 we find the natives again daring and ferocious, especially about York. A soldier was barbarously murdered at Beverley. A settler was slain at York and his house burned. Jones and Chidlow, two farmers, were killed. A woman and her infant were speared, and the house burned over their bodies.

Difficult it is now, surrounded by the comforts of civilised life, and secure in the protection of a peaceful community, to appreciate the dangers and disheartening outrages of warlike blacks, whose descendants now crave alms in spiritless dependence and rags. And yet in 1839 there occurred a fight between two rival parties of natives in the streets of Perth itself, and a little earlier they broke into a store at Fremantle, an enterprise only possible to white men now-a-days, and in 1833 the Old Mill, still standing on Point Belches at South Perth, was looted and the flour stolen. Eventually, in face of repeated murders and constant depredations, retributive measures were taken, and condign punishment inflicted. Two natives were hung in chains in 1840 for the murder of Mrs. Cooke

and her child, on the spot where the deed was perpetrated. The early American pioneers settled their own Indian troubles with a musket and a shot on sight; here, gentler methods prevailed, and the privileges of a white man's trial were allowed. As inevitable, the black man finally retired before the advance of the white, and the trouble died out, except in the extreme Nor'-West, where from time to time evidences of the old leaven still crop up in rare occurrences of spearing and treacherous assault. Western Australia is now as safe a place of residence as the heart of England itself.

Governor Stirling was indefatigable in his efforts to ascertain the geography and capabilities of the new colony. Expeditions were sent out, reports, maps, and data collated, and new settlements projected. On March 6th, 1830, a military station was established at Port Leschenault, and the first white people took up a temporary residence near Bunbury. Enormous areas of land were granted round the estuary. We find Mr. Latour selected 103,000 acres; James Henty (name famous in the annals of early Australia) received 69,000 acres; W. K. Shenton, John S. Roe, the Surveyor General, Mr. Padbury, and many others obtained grants. The Leschenault settlement was one in name only, for reasons now unknown, the settlers being early recalled.

Equally unfortunate was the Augusta settlement, founded May, 1830, on the banks of the Blackwood River, within a few miles of Cape Leeuwin. Here the river presents a magnificent stretch of water, broad and deep, teeming with fish, but separated from the Southern Ocean by a rocky bar. Land was cleared and fenced, buildings erected, wheat and rye planted, and pioneering prosecuted. But food ran short, the schooner from the Swan River with rations failed to arrive, and a spirit of adventurous enterprise prompted the residents to strike out further afield in search of pastures new; and though Augusta lapsed back to a state of nature, the settlement, phœnix-like, appeared again at the Vasse, whither, in 1833, Mr. Bussell wandered in search of lost cattle. So glowing were Mr. Bussell's rhapsodies on his new discovery, with its "seas of waving grass sloping down to the water's edge," that Colonel Molloy, the Government Resident, and many others, exchanged their lands for tracts at Busselton, where a permanent and prosperous settlement was speedily established. Among early arrivals such names as Bussell, Layman, Heppingstone, Turner, Cooke, and Brockman appear. The only sign of previous occupation was a spar, surmounted by a barrel, erected by the French in 1801, on the site of the present lighthouse.

In 1831 King George's Sound was given up as a penal settlement, and that place was included in the jurisdiction of the Colony, while exploratory expeditions were undertaken to connect this then isolated spot with the Swan by land.

Very early was the choice land in accessible districts all taken up. The absence of roads and heavy sand caused the river to become the chief channel of transport, and compelled fresh comers to purchase from original holders who left most of their possessions

The Right Hon. Sir John Forrest, P.C., K.C.M.G., M.L.A.
Premier of Western Australia.

unimproved. In September, 1831, a party, under Mr. Dale, went over the hills and founded York and explored the Toodyay Valley. This year 160 acres of wheat were reaped and about 200 acres put under cultivation by spade labour chiefly. In 1832 a famine threatened; salt pork sold at £10 per barrel, flour 10d. per lb., and fresh meat 2s.

Ever in the forefront, the Press dawned upon the Colony with a manuscript newspaper in May, 1832, and sold at 3s. 6d. per copy, the first printing press arriving in December of that year. A second newspaper was started October, 1836.

Discouraging reports sent home checked immigration. In 1832 only 14 passengers arrived, and 73 in 1833 showed little improvement. At the end of 1835 the total number of ships that had called amounted to 163, the imports to £394,095, and the total passengers landed to 2,281. Still, the struggle was manfully maintained; development of natural resources proceeded apace, and as Governor Stirling reported to Sir George Murray, Secretary of State for the Colonies, "a cheerful confidence in the qualities of the country and a general belief in its future prosperity" was universally held.

January, 1832, saw the first sitting of the Legislative Council. So unsatisfactory was the condition of the colonists at this time that a public meeting was held in Perth calling on Captain Stirling to proceed to England and acquaint the Home Government with the position of affairs.

In September, Captain Stirling sailed (Captain Irwin taking his place at the helm of State) and after two years succeeded in obtaining concessions from the authorities in the shape of "affording further protection and countenance" with a more efficient civic establishment, doubling of the military, and the assurance of more regular food supplies. Satisfaction was expressed on all sides and the new life instilled into the struggling colonists resulted in expansion and confidence. Early in 1834, one pound notes were issued from the Commissariat Office to meet the scarceness of specie. Little indeed could those pioneers have dreamed that beneath their feet lay deposits of virgin specie destined for export in very plenitude of superabundance. Thirty-seven bales of wool were exported this year. Land was worth little outside of actual settlement limits, 1,360 acres on the York road were sold at 6d. per acre in 1835 and another tract of 3,000 acres only realised 4½d., while ewes, with lambs, fetched £5 to £6 10s. per head: a pound of meat was worth, retail, four acres of land, and a pound of local flour one acre.

Ten years of colonial existence, with hard work and determined effort, wrought its sure results. In 1839 there were 2,726 acres under cultivation; the population was 2,152 persons; sheep, 21,038; cattle, 1,308; the colonial revenue was just under £4,000, and in 1840 the "Shepherd" sailed for London laden wholly with colonial produce. Land was still cheap: 50-acre allotments at York were sold in 1842 for 1s. 10d. per acre.

On the twenty-first anniversary of the Colony the revenue had slowly mounted up to £9,596, while the expenditure was £18,566—not altogether as good a showing as those in authority wished to see. And now that exemplification of "man's inhumanity to man," the convict system, cast its shadow athwart the young Colony. Individual effort, though long pursued, had failed to result in individual wealth; the majority of settlers were little better off than when they started. The labour question was considered to contain the solution of the problem, and many advocates clamoured for the introduction of convicts. In December, 1834, Albany had petitioned in this direction and been derided, but in succeeding years it was recognised that something must be done. To make a long story short, the fervid arguments *pro* and *con* and their adherents were all settled by the startling announcement that on 1st May, 1849, Western Australia had been declared by Her Majesty a penal settlement. The convict system, as far as its introduction into the Colony may be regrettable, but in its working out it was manifestly beneficial. On 1st June, 1850, the first convict ship, the "Scindian," discharged its first load of felons at Fremantle. Possibly the date was opportune, for in the following year came news of the gold discoveries in Victoria, followed by an alarming exodus of population that the Colony could ill afford. Transportation ceased in January, 1868, the grand total of convicts introduced being 9,721 prisoners.

One after another new industries were founded. As long ago as 1844 Mr. P. Clifton, of Australind, cut and carted 100 tons of sawn timber to the beach at Bunbury, and by the year's end the settlers had 250 tons awaiting export. The first steam saw mill in the Colony was that erected by Mr. Yelverton, in 1851, at Quindalup; and the nucleus of the Jarrah and Karri hardwood trade was formed at this time.

Four tons of Sandalwood were exported in 1845 as an experiment, and sold at £10 per ton, and for years after this Sandalwood became a medium of exchange at the stores, and a ready means of support for the farmers in slack times. Of nascent industries, the utilisation of the guano deposits in 1848 first called for attention. For long, prices were unsatisfactory and profits more than consumed n the winning, but to-day the Abrolhos Islands, off Geraldton, are the scene of busy enterprise, employing many men and ships to dig, load, and market the deposits.

Dampier, the scientific free-booter, had observed pearl oysters in Sharks Bay in 1699. Then, 150 years later, Lieutenant Helpman discovered several clumps of shell on a shoal in the same locality. It was only after a passage of arms between the Home and Colonial authorities that the right of control of the shell fisheries was decided in the interests of the public. Up to 1866 little was done to establish a shell industry. The export in that year reached £6 only, chiefly from Nickol Bay. However, 1867 witnessed a boom when Mr. Tays, by careful search, procured several tons, estimated at £1,000. By December, 25 tons were won and the export for the

year stood at £556. A pearling fleet was equipped in 1868 and a successful season for 12 ships resulted in an export of shell valued at £5,554. The industry was now established firmly.

As early as 1861 flour was exported, a noteworthy fact in the light that in 1896 the Colony imported nearly 15,000 tons to meet the requirements of a vastly increased population.

The early sixties show a phenomenal expansion of industry and trade; on all sides vigour and enterprise brought their reward, From £95,789 in 1861, the exports rose by successive gradations to £192,635 in 1868, and the Colony in the latter year was free of public debt. Wool drew the most capital to the Colony, the export reaching £98,254 in 1868. Wine was exported in small quantities, and a considerable amount consumed locally. Cotton, for which climate and soil are both in many places adapted, was never a commercial success. Like sugar elsewhere, want of cheap labour, and not white at that, barred profitable prosecution. With a population of some 20,000 all told, small capital to command, difficulties of transportation and distance to market, it must be admitted that the Western Australians had achieved marvels in the way of progress and development. The task was a formidable one, worthy the mettle of those to whose lot it fell to undertake it. Truly, the best qualities of the English race, dormant perhaps amidst the comforts of old country life, are seen to their greatest advantage in pioneering work across the seas, in the subjugation of Nature in her harshest moods, and in bringing within the limits of civilisation new heritages for the children of the Empire.

It was in 1855 that the question of Responsible Government was first raised, and at intervals cropped up for years. In 1874 a petition to the Imperial Government to this end was presented and refused. In 1889, at the general elections, public opinion expressed itself emphatically in favour of self-government, and a Constitution Bill was passed and submitted to Britain.

After much delay the Act passed both Houses of the Imperial Government, and received the Royal assent on 25th June, 1890, the news bringing general rejoicing throughout Western Australia and her sister colonies.

On 21st October, 1890, Sir William Robinson, the Governor, proclaimed the new constitution at Perth amid great jubilation. On 30th December, the first Parliament under Responsible Government assembled, with the Hon. John Forrest as Premier, a position he has since held with credit and honour. At this time the white population of the Colony was under 50,000, coloured population 6,000, Chinese 917.

The first Ministry to hold office under the new Constitution consisted of:--John Forrest, C.M.G., Colonial Treasurer; George Shenton, Colonial Secretary; Septimus Burt, Q.C., Attorney General; William Edward Marmion, Commissioner of Crown Lands; Harry Whittall Venn, Commissioner of Railways and Director of Public Works. Although changes have occurred in the

personnel of the original Cabinet from time to time the Forrest administration has remained continuously in power. The present Ministry consists of:—Rt. Hon. Sir John Forrest, P.C., K.C.M.G., Premier and Colonial Treasurer; Hon. F. H. Piesse, Director of Public Works and Commissioner of Railways; Hon. George Throssell, Commissioner of Crown Lands; Hon. H. B. Lefroy, Minister of Mines; Hon. R. W. Pennefather, Attorney General; Hon. George Randell, Colonial Secretary, Minister of Posts and Telegraphs, and Minister of Education.

Responsible Government, the discovery of gold, and the beginning of our present national prosperity are synchronous one with the other. Population and wealth really date from this period, and no one can look forward to the future with feelings other than those of hope and confidence.

Perth, the capital, has grown apace. Buildings of brick and stone dotted the sides of St. George's Terrace in the early thirties. A brewery was established in 1836, followed by a bank in 1837 and the commencement of the Perth church in 1841.

In June, 1838, there were granted in Perth 422 town allotments and 15 suburban, the value of improvements in the city being estimated at £50,000, and in Fremantle £28,000. Twelve months later the first proposal for assessments for improvement purposes was mooted. Perth, as it appears to-day, built up in its present handsome appearance (principally since the advent of the gold seekers a decade ago) is now one of the most beautiful capitals in Australia. St. George's Terrace, broad and smooth, lined with well-built banks and structures of high architectural merit, is one of *the* streets of the Continent.

Cathedrals, churches, schools, the Post Office and mass of public offices, the Mint, Observatory, Museum and Free Library are worthy of special admiration, the Perth Railway Station being finer than anything Sydney, Melbourne, or the more advanced capitals of the East can boast. Parks, reserves, and public gardens, the lungs of the city, afford breathing spaces for the people for all time, providing *rus in urbe* at one's office door. At the stores and warehouses may be obtained every commodity of every-day life, at reasonable prices. Numerous hotels, run on the best lines, remind the visitor that the comforts of life may be enjoyed even at the antipodes. But the glory of Perth is the river Swan, on the banks of which she is built. Here the river widens to a great sheet of water, bounded by the opposite peninsula, on which South Perth extends her villa residences down to the water's edge. On the placid surface a fleet of yachts and pleasure boats ply. Steamboats provide outings to scenes of interest along the reaches of the river, while in the hottest weather the sea-breeze blows cool up the broad channel from the Indian Ocean. Every kind of sport has its devotees. Australians love the open air, and cycling, cricket, football, tennis, yachting, and last but by no means least, horse-racing, are indulged in with a vim and enthusiasm peculiar to the dwellers below the Southern Cross.

If to outside enterprise, in the first place, Western Australia owes accurate knowledge of its topographical features, since its earliest foundation the importance of examining its vast interior was never lost sight of on the spot. Thirty years before Burke and Wills lost their lives East in Victoria, while crossing the Continent, systematic exploration, under difficulties and hardships unequalled anywhere, was being undertaken to fill in the map of a million square miles that was at that time an absolute blank. Those pathfinders of the wilderness, pioneers of a country's commerce, have writ their names large on the scroll of fame. Collie, Preston, Roe, Dale, Bannister (who first opened the track to King George's Sound), Hillman, Moore; these and many others located the rivers, hills, and forests in the thirties, opening up the land; valuators as it were of the national estate. In 1841, after six long months, Edward John Eyre accomplished a journey that ranks amongst the highest feats of human endurance. Starting from Fowler's Bay, attended only by a single companion and a black boy, two natives murdered his sole friend Baxter and stole the provisions. Eyre and the faithful boy were left with hundreds of miles ahead and 40lbs. of flour and four gallons of water to do it with. Nothing daunted, the trip was eventually accomplished after incredible hardships, and Albany reached. Much valuable topographical lore was obtained. What Eyre accomplished in half a year will, it is confidently expected, become a matter of days, almost of hours, at no very distant date, when a transcontinental line shall have bound Fremantle with bonds of steel to Adelaide and the whole of Eastern Australia.

W. N. Clark, in 1841, discovered immense karri and jarrah forests West of Albany, and reported on their value to the State, commenting also on the fact that the whole whaling industry prosecuted round the coast was solely in the hands of the American ships, upwards of 150 sail.

Exploration in the North had not been neglected. Captain George Grey, in 1839, discovered and named the Gascoyne, Murchison, Irwin, Greenough, and other rivers. Having lost his boats, the party was compelled to return on foot to Perth, some hundreds of miles, tattered, torn, and exhausted. This led to the establishment of a settlement adjoining Port Grey at Champion Bay, now the flourishing town of Geraldton.

In 1846 the Gregory brothers visited the salt lake region of the interior, first seen by J. S. Roe on the borders of the Yilgarn field in 1836. Coal was discovered at the head of the Arrowsmith river. Two years later A. C. Gregory found a galena lode on the Murchison river, while Governor Fitzgerald examined and named the Geraldine mine.

In 1854 Robert Austin explored the present Murchison Goldfield country, and, in his report issued subsequently, stated that the country around Lake Austin and Mount Magnet was probably "one of the finest goldfields in the world." How true his prophecy was has been proved by actual development over 30 years later.

A. C. Gregory continued his career as a pathfinder. In 1856 he journeyed from the Northern Territory of South Australia along Sturt's Creek in the extreme North-East of this Colony and surveyed the Denison plains South of the present Kimberley Goldfield.

F. T. Gregory is responsible for much pastoral land added to the national domain. In 1857 he explored the Murchison country, and the following year the Gascoyne. In 1861 he traversed the back country near the head waters of the Ashburton, Fortescue, DeGrey, and Oakover Rivers, inland from the North-West coast.

Clarkson, Dempster, Harper, Delisser, Lefroy, all these and many more, helped materially to fill in the vacant spaces on the map of Western Australia. Then came C. C. Hunt in 1864, who, exploring Eastward, passed over the site of Coolgardie, and laid down the track for the gold-seekers, over a quarter of a century later. We first hear the name of John Forrest, our present honoured Premier, as an explorer of note in 1869, when he made a short expedition to Lake Barlee; camped on the summit of Mount Margaret, in vain search for the remains of the lost Leichardt, and passed over a region rich in gold, the silent solitudes of those great plains now being the scene of busy townships, where the music of the stamps denotes employment and prosperity to thousands.

Next year John Forrest, accompanied by his brother, successfully accomplished the journey from Perth to Adelaide *via* Eucla, eclipsing Eyre as to time, and establishing his fame as an explorer. Equally important in results was Forrest's examination, in 1874, of the spinifex deserts, traversed hurriedly by Warburton, East of the Murchison to the border. Careful reports and close inspection added much to the scant knowledge of the great interior.

Ernest Giles ranks high as an explorer. His incursions into the bush were lengthy and persistent. Only on his third trip did he succeed in opening up the supposed desert of Central Australia, a task that had baffled many explorers previously. Camels had superseded horses and enabled him to accomplish one waterless stage of 325 miles across the Great Victoria Desert. The Coolgardie country was traversed and Perth reached after having travelled 2,575 miles in five months.

Alexander Forrest did much useful work, and his name is included on the roll of those who opened up our grand pastoral country, together with those of O'Donnell, Carr-Boyd, Stockdale, Johnston, and E. T. Hardman, the latter mapping and locating the auriferous areas of Kimberley.

In 1891, David Lindsay, heading an expedition fitted out by Sir Thomas Elder, traversed a distance of 2,745 miles, exploring an area of 80,000 square miles. The Calvert Expedition, in 1896, experienced fearful hardships in the desert East of Roebourne, leaving the bones of C. F. Wells and G. L. Jones as sorrowful mementoes of the invasion of Nature's forbidding wastes. Hubbe, from South Australia, crossed the border in 1896, and struck across to Coolgardie, in an endeavour to open up a stock route. He returned

by way of Eucla without finding much possible country. David Carnegie, in the same year, traversed 3,000 miles, with a well-equipped party, leaving civilisation at Lake Darlôt, and striking North-North-East to Hall's Creek, in the Kimberley District; following the border thence South to Lake Macdonald, a course was shaped for Coolgardie. It was proved that a stock route from Kimberley was impossible, and that little if any auriferous country existed so far East. What our principal explorers delineated in long lines across the map has been rounded out and amplified since 1887, when gold brought a great influx of strangers, by the efforts of numerous private parties of prospectors, who have scoured the country far and wide in search of metalliferous indications; nor must a meed of well-earned merit be left unbestowed upon squatters pursuing their avocation on distant and isolated runs, and who have, from time to time, in their wanderings plotted and charted thousands of square miles of our vast interior territory. The history of Western Australian exploration forms a whole chapter in itself, and hands down to posterity names worthy of all honour: of pioneers, pathfinders, and explorers, the embodiment of British pluck and tenacity, who have carved a heritage from the wilderness for the race, and stamped their names for all time upon the annals of their country.

Periods of depression had been the lot of all the Australian colonies at various times. More than once already had the dark clouds that overhung the horizon been scattered by the magic of new-found auriferous wealth. As in Victoria, so in Western Australia, hitherto the Cinderella of the colonies, the announcement of gold proved the talisman that accomplished in less than a decade what agronomic pursuits, subsidised by the bonus of cheap convict labour, had failed to do in over half a century. From the obscurity and comparative poverty of the recent past, the Colony has sprung almost at a bound to a forefront position in the rank of nations, has dazzled the world with the splendour of her auriferous resources, has opened up avenues of commerce and prosperity hitherto not even dreamed of, and has disclosed opportunities for the profitable employment of capital, labour, and skill to a degree only limited by the energy and ability of those to whom the legacy of a beneficent Providence has descended. Not altogether unsuspected, but certainly ignored in the past, it was found that Nature, with lavish hand, had dowered the Western portion of the island continent with a profusion of mineral wealth unsurpassed in extent in the known world. Seldom has such an aggregation of capital and labour, population and commerce, been witnessed as has within the past few years congregated on the sandy shores of Western Australia. Sweeping inland Eastward over the sterile plains, following the paths of the explorers to the South Australian border, undaunted by the perils of the inhospitable bush, the barren stretches of salt lake and dreary spinifex, the waterless wastes of desert sand, and the burning rays of a semi-tropical sun, those argonauts of the nineteenth century have founded an El Dorado in a sahara, bringing in

their train the blessings of civilisation, building busy cities and startling the echoes of the silent wilderness with the hum of machinery and the bustle of commerce. And, while surprise is often expressed that discoveries were not made earlier in the course of numerous explorations, it must be borne in mind that the Colony, with its million square miles of territory, was inhabited only by a mere handful of people, settled along the more favoured regions near the coast; that the interior was more of a *terra incognita* than Central Africa; and that Nature, with compensating hand, had planted her treasures in the most desolate and forbidding portion of the sterile wastes inland from the coast.

Ever since Victoria had been "uplifted in a night, as it were, to the position of a nation and a power in the world" by the exploitation of her gold deposits, portions of this Colony had been prospected in a desultory way with intangible results. It was not until 1884 that Mr. Hardman, the Government Geologist, by his discoveries in the far North, placed the embryo industry upon a practical footing. Expeditions were equipped, gold was found in payable quantities, both reef and alluvial, and with the rush of diggers and speculators from the Eastern colonies the reign of prosperity may be said to have actually commenced. The Kimberley Goldfield was proclaimed 19th May, 1886, and a Goldfields Act passed by Parliament in that year. The population increased by 2,000 souls. Intense excitement prevailed. A repetition of the golden days of California, of New Zealand, Victoria, and Queensland was expected. Results failed to fulfil anticipations, and a disastrous exodus ensued. The roads were strewn with abandoned vehicles and supplies, and yet this devoted band of diggers, hopeful as the miner ever is, undaunted by adverse fortune and evil times, became the nucleus of the army of prospectors that scattered to the Southward and became the pioneers of the Pilbarra, Ashburton, Murchison, and Eastern Goldfields.

And what a transformation was effected in a few brief years! Thirst, famine and fever—those guardians of Nature's treasure-house—are overcome. In the wake of the army of pioneers there follows a vast commissariat of supplies for the men at the front. Railways bind the busy hives of industry, springing up like magic in the interior, with bands of steel to the growing ports of the sea-coast. A fleet of vessels from all quarters of the globe is freighted with merchandise for the new West, and Bayley's rich find at Coolgardie becomes the Mecca of the treasure-seeking pilgrims flocking inland in obedience to the *auri sacra fames* that lies inherent in the human breast.

From the briefest of paragraphs Western Australia has grown to whole pages in the world's history.

The pioneers of Kimberley, scattered afield, with ranks reinforced by adventurers from abroad, opened up new country over hundreds of miles of territory. Mallina and Pilbarra Creek, Nullagine, Marble Bar, with its barrier of mottled quartz and

THE FIRST MINISTRY UNDER RESPONSIBLE GOVERNMENT, 1890.

Hon. H. W. Venn (*Railways and Works*). Hon. Geo. Shenton (*Col. Sec*)

Hon. John Forrest, C.M.G., (*Premier*).

Hon. Sept Burt, Q C. (*Atty. Genl.*) Hon. W. E. Marmion (*Crown Lands*).

THE PRESENT MINISTRY, 1900.

Hon. Geo. Throssell (*Lands*). Hon. H. B. Lefroy (*Mines*).

Right Hon. Sir John Forrest, P.C., K.C.M.G. (*Premier*).

Hon. Geo. Randell (*Col. Sec., Posts & Tels.*) Hon. R. W. Pennefather (*Atty. Genl.*)

Hon. F. H. Piesse (*Works and Railways*).

jasper, the Shaw, Oakover, and Nickol yielded up their riches. The great Murchison followed, and in 1892 the gold output for the year totalled £226,283, an increase of nearly 100 per cent. over the preceding year. In 1892 the world was electrified by the news of Bayley's rich find at Coolgardie, where chunks and slabs of solid bullion were chopped out with a tomahawk. The news was noised abroad; from every camp in the interior, from the cities of the coast land, from the East, from America, and the outside world, there poured forth a steady stream of eager humanity, rolling Coolgardiewards. From a collection of tents, brush humpies, and blanket shelters, covering the dusty ground and peopled by a motley array of diggers in every garb, there sprang a handsome city with wide streets and well-built structures, like a mushroom, almost in a night. To-day Coolgardie will compare favourably with any city of its size in the world—progressive, up-to-date, and equipped with all the comforts and amenities of civilisation at its best.

In 1895 over fifty million pounds were subscribed, chiefly in London, on behalf of Westralian flotations.

Kalgoorlie, first known as Hannans, after its founder, commenced existence in June, 1893, and now measures its gold output literally by the ton. No gold camp in the world excels the charmed circle of which Kalgoorlie is the centre—acre for acre, the richest known spot on earth. The bonanzas of Kalgoorlie and the fortunes they have yielded are now matters of history. Memories of Virginia City or Johannesburg are recalled in the career of the Coolgardie Prospecting Company, which was wound up in October, 1898. It was formed in 1893, in Adelaide, to send Pearce and Brookman to the new goldfields of the West. The original capital was 10 contributing shares of £15 each and five fully paid-up shares. The prospectors reached Coolgardie and, after refusing a claim, pushed on to Hannans, where they staked out 330 acres. That small beginning resulted in the possession of eight mines, viz., the Great Boulder, Lake View Consols, Associateds, Ivanhoe, Lake View South, Lake View Extended, and Boulder No. 1, the aggregate value of which, at the date of winding-up the syndicate five years later, was £9,275,075. The amount distributed among Adelaide shareholders in dividends was approximately 950,000 in shares and £3,421,000 in cash, making a total, with the then value of the mines, of £13,646,750. Since then values have expanded enormously and the single talent buried in the ground has yielded millions.

In 1895 the revenue of the Colony rose to £1,438,717, an increase of half a million over the preceding year, while the population rose to 101,000. The Colonial Treasurer, in his last Budget Speech, estimated the revenue of the present financial year at £2,795,480, and the population now stands at 170,000 persons.

Gold-mining is now our chief industry. Out of the track of the world's commerce, Western Australia had long held the unenviable reputation of being almost incapable of supporting a population of any importance. Supplies were scarce and dear; distance from the centres of civilisation enormous, and means of transport slow and

inadequate. Every one of these drawbacks to progress has been met and overcome by pluck and perseverance, and with the helpful encouragement of a Government alive to the importance of the issues at stake.

To-day the visitor to the goldfields can traverse the paths of the pioneers in an express train, camp on the site of their early hardships in a well-appointed hotel, follow the windlass and cow-hide bucket of the prospector's insecure shaft in a safety cage impelled by the most modern machinery, and can witness on every hand the *cosmos* achieved by human skill and enterprise from the *chaos* of Nature's raw material in the wilds of the primeval desert.

Western Australia has achieved its growth and present enviable position within the memory of living man. There is still alive a small handful of the early pioneers, to whom the first days of the Colony are not merely a tale re-told, but a personal remembrance. In this brief span the Colony has emerged from its position as merely a portion of *Terra Australis incognita*, and has become an integral part of the British Empire. A network of steel rails now connects the more settled centres, the capital and principal ports, with the newly opened districts out back. There are 1,349 miles of railway open to traffic already, with more authorised for construction—about one mile for every 133 head of population. The goldfields have been tapped, and the old difficulties of transportation have vanished. The electric wire has followed close on the heels of the prospector, till it is now possible to despatch a cable to Europe direct from the remote mining camps on the frontier. It must be remembered that, consequent on the mining boom, the country was flooded with population almost without warning; cities sprang up like magic over a vast and scattered area far inland, and while providing all the elements for successful nation-building on a comprehensive scale, yet threw upon the Government a burden of responsibility requiring almost superhuman efforts to meet and overcome. In the entire absence of surface water, wells, dams, and reservoirs had to be provided everywhere, while in all the growing centres of population throughout the length and breadth of the Colony, buildings have had to be erected for the administration of Government: hospitals, court-houses, police stations, post and telegraph offices, railway stations, and all such requirements of a civilised British community empire-building afield. The face of the country is dotted with State schools; education is free to all; over 14,000 children were on the roll last year; the labourer and artisan in the bush or at the front can educate his family while pioneering. Every soul of those tens of thousands out back must consume a certain quantity of fresh water daily or perish; Nature having overlooked the point, man's ingenuity had to provide a supply. Condensers were put up to treat the brine of the salt lakes, ten times salter than the sea. The rivers were made with their beds of sand on top, the water below. In 1897-8, a dry year, there was needed to keep the railway to the Eastern Goldfields open 55,440,000

THE ROYAL COMMISSION—President and Officers.

Ernest Williams (*Vice-Chairman Mineral Committee*).

M. C. Davies, (*Vice-Chairman of Timber Committee*).

Hon. H. W. Venn (*President*).

George Aytoun (*Secretary*).

H. F. Keep (*Collector and Acting Secretary*).

F. T. Trouton (*Assistant Curator*).

A. G. Holroyd (*Curator*).

gallons of water in 42,000 travelling water tanks hauled on ordinary and special trains at an expenditure of 228,606 train miles, representing £49,531. To supply Coolgardie and the surrounding country with water, a gigantic water supply scheme is now being carried out by the State, under the superintendence of the Engineer-in-Chief, Mr. C. Y. O'Connor, involving the construction of a dam forming a lake seven miles in length, the laying of 60,000 pipes, each 28ft. long, to extend 325 miles from end to end, the contract price for the pipes alone being £1,025,124.

Jetties and harbours have been provided over a coast line of 1,200 miles, the principal effort in this direction being the Fremantle Harbour Works, by which a port has been made, enabling the leviathans of the mail-carrying lines to moor with safety inside the mouth of the Swan River. The design is to make Fremantle the first and last port of call in Australia, the Western terminus of the proposed transcontinental railway, a second Vancouver South of the equator. Already the great "Barbarossa" of the North German Lloyd line and H.M.S. "Royal Arthur," drawing 26ft., have swung in the basin and tied up to the wharf. One and a-half million cubic yards of solid rock have already been blasted out and dredged, and the works are being pushed on to a rapid completion.

No country in the world offers more liberal inducements to the actual settler than Western Australia, where land is practically given free to the man who will honestly endeavour to make two blades of grass grow where only one grew before.

Our Forest resources form a national asset of a magnitude hardly realised. Out of a total of 47,400,000 acres over all the colonies upon which useful marketable timber is growing, the forest surface of Western Australia covers 24,400,000 acres, or fully one-half of the total, and her marketable timber now growing, deducting one-third for waste in sawing, is worth no less a sum than £124,000,000. The karri, jarrah, tuart, and other hardwoods are now being utilised and shipped to every quarter of the globe.

Coal is being mined in the South-West; the locomotives on the State railways find it excellent in use. Tin and copper each add their quota to the aggregate of wealth. Even diamonds have been proved to exist and are being sought for.

What the future holds in store may to a great extent be gauged from the record of past achievement. Our auriferous zone stretches, with but few breaks, some 1,500 miles from North to South, and nearly 200 miles wide, and contains 17 declared goldfields covering a total of 324,111 square miles, every acre of which is under the jurisdiction of a Warden, with courts of law, police protection and efficient government provided everywhere. Truly it is a noble heritage! Worthy of those who made it; worthy the best traditions of the race which is so faithfully carrying out the obligations of the trust imposed on it in the development of so great a responsibility; worthy to rank as one of the brightest gems in the Imperial diadem of our beloved Queen.

FACTS AND FIGURES.

POPULATION.

Population.—Although Western Australia occupies one-third the area of the entire continent, her population is the smallest of the group. Commencing in 1830 with 1,767, we find the decennial returns as follows:—1840, 2,311; 1850, 5,886; 1860, 15,227; 1870, 25,084; 1880, 29,019; 1890, 46,290. After this year the advance is much more rapid, consequent upon the influx of the gold-seekers. Thus, 17,008 people were added to the population in 1894, an increase of 26·14 per cent.; 19,163 in 1895, or 23·35 per cent., bringing the total to 101,235. This was eclipsed in 1896, when the increase mounted to 36,711, or 36·26 of the whole; 1897 is responsible for 23,978 of an increase, or 17·38 per cent. The population in 1899 was 171,022, an increase of 1·72 per cent. There are, and always have been, more males than females in Western Australia, the proportions varying widely. The first record dates from 1837, when the number of females was 62·13 to every 100 males. In 1858 it sank to 49·39, the convict system, no doubt, being accountable for the disproportionate ratio. Rising to 74·33 in 1889, it fell to the lowest point ever touched, 42·28 in 1896, when the country was flooded with gold-seekers and miners. The proportions are adjusting themselves slowly and steadily, the figures for 1899 showing an increase per cent. of 4·74 for females against only 0·21 for males, the births of female children exceeding those of males by 596, and the excess of arrivals over departures of females being 940 against an excess of departures over arrivals of males of 887.

Of Chinese we have few, the number on 31st December, 1898, being 1,876, and the number is decreasing, there being a decrease by death and emigration during 1898 of 61. The percentage of Chinese to total population is 1·12 per cent.

Births, Deaths, and Marriages.—For 1898 the figures run—Births, 4,968, or 29·38 per 1,000 of population; deaths, 2,716, or 16·05 per 1,000; marriages, 1,674, or 9·89 per 1,000. In 1899 there were 5,224 births and 2,384 deaths, showing an excess of births over deaths of 2,840. For 1898 Western Australia had the highest rate in births, deaths, and marriages in comparison with all other colonies of the Australasian group. Compared with European countries, the Australian death-rate is very low.

The Western Australian Bank, Perth.

The National Bank of Australasia, Perth.

FINANCE.

The revenue of the Colony for the year 1889 amounted to £442,725. Ten years later, in 1899, the revenue for the financial year ended 30th June amounted to £2,478,811, and for the calendar year to £2,633,081. The amount derived from taxation was £947,222 or 35·97 per cent. of the whole, being derived chiefly from Customs. The other sources of revenue were contributed as follows:—Land, £132,470 or 5·03 per cent.; Mining, £95,214 or 3·62 per cent.; Public Works, £1,152,124 or 43·75 per cent.; Postal and Telegraphic, £203,972 or 7·75 per cent.; other sources, £102,079 or 3·88 per cent. This works out at £15 11s. 10d. per head of mean population, of which Customs and Excise are responsible for £5 3s. 4d.

The expenditure for 1899 amounted to £2,396,448 or £14 3s. 10d. per head. Comparing the Revenue and the Expenditure, it will be seen that the Colony is not only living well within its means but has a handsome balance on the year's transactions.

Public Works and Railways have absorbed a large percentage of both revenue and loan money; in fact, during the year ended 30th September, 1897, out of a total public expenditure of £3,039,757, this department is responsible for the outlay of nearly half, and in the two years 1896-98 the Government expended on public works no less a sum than five millions of pounds. The total of loan moneys expended to 30th June, 1898, by the Works Department amounts to £8,583,750, of which Railways absorbed £5,931,472, with over a million for Harbours and Rivers Improvements.

Looking at the credit side of the ledger, the railway system earns, after paying all working expenses, a net profit greater than the Colony has to pay for interest on the capital expended, and allowing for sinking fund besides. In other words, our large loan account falls lightly on our small population, for the reason that it is mainly spent on reproductive works.

The public debt of Western Australia outstanding on 31st December, 1899, amounted to £10,512,348; the accrued sinking fund to £338,650, leaving a net indebtedness of £10,173,698, or £59 9s. 9d. per head of estimated population. Of the debt, £32,500 bears interest at 6 per cent., £83,100 at 5 per cent., £79,700 at $4\frac{1}{2}$ per cent., £4,082,960 at 4 per cent., £1,263,630 at $3\frac{1}{2}$ per cent., £71,000 at $3\frac{1}{4}$ per cent., and £4,875,473 at 3 per cent., an average rate, over all, of 3·49 per cent.

It must be remembered that, within the last few years, tens of thousands of people have flocked into the country and scattered over a vast area unprepared for their reception, necessitating an immediate equipment at great cost of public works, railways, harbours, water supply, and other pressing needs wherever settlement had taken root. The loan money has been expended for the

prosecution of works of a permanent character, by which succeeding generations will be largely benefited, and from which returns are forthcoming, and will increase, with access of population, steadily, especially in the case of the railways and the Coolgardie Water Scheme.

MONETARY INSTITUTIONS.

Royal Mint.—The Perth branch of the Royal Mint was opened for the coinage of gold on 20th June, 1899, and is now in a position to deal with an annual coinage of £3,000,000. Special facilities are provided by the Government in the matter of carriage and gold escort on parcels consigned to the Mint. The amount of gold received at the Mint up to 31st December, 1899, was 209,306ozs. 4dwts. 19grs., the largest amount deposited in any one month being 42,321ozs. 11dwts. in August.

Banks.—There is no State bank, so-called, in Western Australia. In 1894 the Agricultural Bank was established by Act of Parliament, under which advances are made to actual settlers for the purpose of effecting improvements on land not otherwise encumbered. Advances are paid proportionately as improvements are effected, and all loans have a currency of 30 years, at 5 per cent., the borrower repaying the principal, after five years have elapsed, in 50 half-yearly instalments.

There are six banks of issue operating in the Colony, as follows:—

Western Australian Bank, head office, Perth, with 27 offices in the Colony; commenced business, 1841.

National Bank of Australasia, Limited, Melbourne, 9 offices; commenced, 1866.

Union Bank of Australia, Limited, London, 18 offices; commenced, 1878.

Bank of New South Wales, Sydney, 4 offices; commenced, 1883.

Commercial Bank of Australia, Limited, Melbourne, 6 offices; commenced, 1888.

Bank of Australasia, London, 7 offices; commenced, 1894.

It is interesting, from an historical standpoint, to note that a local bank was first established in the Colony in January, 1837, with a capital of £10,000. It opened for public business in June, and 12 months later declared a dividend of 14½ per cent. In April, 1841, a proposition to transfer its business to the Bank of Australasia was carried, and that bank opened its doors to the public in May of that year, simultaneously with the issuing of the prospectus of the present Western Australian Bank. The Bank of Australasia withdrew from the Colony some years afterwards.

In 1898 the note circulation of the six banks was £330,673 and their total average liabilities £4,037,252, as against which the coin and bullion on hand amounted to £1,827,244 and the total assets to £5,420,479. The total paid-up capital for all banks of issue oper-

ating in the Colony on 31st December, 1898, was £10,208,953. As for rate of dividend last declared, the Western Australian Bank ranks as premier, with a rate of 17½ per cent., the rest ranging from 9 per cent. to 2 per cent. per annum. The judgment and intelligence observed in carrying on the banking business of the Colony have gone far to minimise any effects from overtrading that may have occurred as a result of the late mining boom and the over-inflation of values consequent upon it.

Savings Banks.—The only Savings Banks in Western Australia are those in connection with the Post Office. Every facility is afforded to the working classes and the poorest to exercise thrift by the investment of their savings safely and profitably in the various branches of this bank scattered over the Colony. Interest at the rate of £3 per centum is allowed. Deposits may be made from 1s. upwards to £150 in one year, with an allowable total to each depositor of £600 in all.

The table below will show the growth of the Post Office Savings Bank year by year for the last ten years, its expansion, and present status :—

Year.	No. of Offices.	Deposits received.	Excess of Deposits over Withdrawals.	Interest for the year.	No. of Accounts.	Balance due Depositors end of year, with Interest.
		£	£	£	£	£
1889 ...	19	18,697	253	1,084	2,965	32,146
1890 ...	20	21,552	1,353	1,115	3,014	34,615
1891 ...	20	38,498	10,151	1,413	3,564	46,181
1892 ...	20	54,610	13,952	1,856	4,443	61,989
1893 ...	23	39,211	11,775	1,160	4,745	74,925
1894 ...	24	146,387	62,878	3,515	6,310	141,319
1895 ...	24	217,930	74,250	6,245	8,374	221,815
1896 ...	31	520,015	228,271	10,523	16,160	460,610
1897 ...	38	1,068,322	378,138	17,334	26,317	856,083
1898 ...	55	1,231,637	189,117	26,856	29,791	1,072,057
1899 ...	59	1,057,023	14,274	29,848	29,371	1,116,178

Life Assurance.—There are seven life assurance companies operating in the Colony. During 1898, the last year for which the figures are available, 3,045 policies were issued, covering an assurance of £627,344 14s. 2d., with annual premiums of £21,155 13s. 6d., in addition to 263 endowments, assuring £18,730, with £993 18s. 6d. in annual premiums. On 31st December, 1898, there were 14,178 assurance policies and 1,181 endowment policies in force in the Colony, covering respectively £3,081,061 9s. 2d. and £65,722 10s. 2d., and one annuity.

Friendly Societies.—These make a strong showing in the Colony, and are, generally speaking, in a flourishing financial position. In all, there are 15 of these societies with 68 branches and 4,543 members, enjoying a total income of £15,557 1s., and expending £12,975 17s. 1d., their capital being £35,409 9s. 6d.

These figures are for the year 1898, and the following table shows their distribution:—

	No. Members.	Income, 1898.	Expenditure, 1898.	Capital at end 1898.
		£	£	£
Manchester Unity I.O.O.F.	907	3,755	3,076	16,559
Independent Order of Rechabites ...	427	1,222	1,148	9,970
Hibernian Australasian Catholic Benefit Society	276	790	655	1,319
Sons of Temperance	141	377	353	656
I.O.O.F.	73	327	367	119
Ancient Order of Foresters	861	2,666	2,077	2,335
United Ancient Order of Druids ...	367	1,242	1,102	1,025
Protestant Alliance Society	340	1,513	1,220	1,075
Irish National Foresters	157	493	410	450
Grand United Order of Oddfellows ...	186	584	546	288
Australian Natives' Association... ...	504	1,898	1,507	1,331
G.U.O. of Free Gardeners	304	682	510	275

Building Societies.—There are nine Building Societies in the Colony—three in Perth and one each in Fremantle, Geraldton, Albany, Northam, Bunbury, and Guildford—the oldest having been established in Perth in 1862.

TRADE AND COMMERCE.

Imports and Exports.—In 1898 the value of the goods imported in Western Australia was £5,241,965; that of goods exported being £4,960,006, showing an excess of Imports over Exports of £281,959: the total value of external trade thus being £10,201,971. The largest proportion of trade was with the Australasian Colonies and the United Kingdom. Per head of the population, the average value of the Imports was £30 19s. 4d., of the Exports £29 6s. 1d., of total trade £60 5s. 5d.

Of the total trade done 42·59 per cent. was with the United Kingdom, 51·04 with the Australasian Colonies, 2·98 with other British possessions, and 3·39 with Foreign countries.

The principal Imports for 1898 were: Machinery, £799,724; Textile Fabrics and Dress, £685,867; Food and Drink, £1,776,459; Metals and Minerals (excluding Gold and Silver), £358,942; Live Animals, £263,699. The principal Exports were: Gold, £3,990,698; Wool, £287,731; Jarrah, £189,741; Karri, £136,371; Pearl Shell, £78,784; Sheep Skins, £39,278; Kangaroo and Opossum Skins, £5,267, and Coal £25,827.

In 1899 the value of the goods imported into Western Australia was £4,473,532, that of goods exported being £6,985,642, showing an excess of exports over imports of £2,512,110, the total value of external trade thus being £11,459,174.

The Union Bank of Australia, Ltd., Perth.

The Bank of New South Wales, Perth.

The largest proportion of trade was with the Australasian Colonies and the United Kingdom.

Per head of the population, the average value of imports was £26 9s. 9½d.; of exports, £41 7s. 3½d.; of total trade, £67 17s. 1d.

Of the total trade done 46·46 per cent. was with the United Kingdom, 45·81 with the Australasian Colonies, 3·10 with other British possessions, and 4·63 with foreign countries.

The principal exports were:—Gold, £5,451,368; wool, £423,296; jarrah, £375,433; karri, £177,622; ores (copper and tin), £64,615; pearl shell, £90,647; skins (sheep), £43,816; kangaroo and opossum skins, £18,122; and coal, £45,283.

The principal imports were:—Machinery, £409,282; railway plant, £139,867; sugar, etc., £116,485; live stock, £195,513; hardware, £189,775; and apparel and drapery, £465,470.

MANUFACTURES.

Manufacturing and Industrial enterprise in Western Australia has ever had the support and encouragement of the Government of the Colony. According to the latest returns available we find that in our very limited community of 170,000 persons all told, and with a home market of the most recent creation, the Colony in 1897 possessed 487 industrial establishments, employing 9,689 hands in all, 9,265 being males and 424 females; while for the year 1898 a steady increase is to be seen in an advance to 595 establishments, employing 9,895 persons, 9,253 males and 642 females. Thus 218 more females were enjoying wages in the latter year, an increase of over 50 per cent. There are in the Colony 19 flour mills, which during the year turned 438,265 bushels of wheat into 8,460 tons of flour; 53 aerated water and cordial factories, employing 328 hands, and turning out 890,135 dozens of waters and 15,892 dozens of cordials; 27 breweries, which brewed 3,278,008 gallons of beer and stout; 13 boot and shoe factories finished and made locally 207,957 pairs of boots and shoes, and 190,891 pairs of uppers; brickworks and potteries to the number of 32 manufactured 26,810,900 bricks, employing 314 people to do it; 35 saw mills at work in the forests gave employment to 2,961 hands, 1,410 horses, and 905 bullocks, who assisted to produce 103,042,991 super. feet of timber. The Colony possesses seven electric light works, which supplied during the year 459,847 Board of Trade units of electricity, the land and plant representing an investment of £68,385. Albany, East Fremantle, and East Perth are the sites of three gas works, which supplied 56,988,680 cubic feet of gas, land and plant being valued at £77,310: seven soap and candle works output 20,381cwt. of soap and 1,169,475lbs. of candles, the value of the output being £35,813; three tobacco and cigar manufactories operated upon 77,161lbs. of imported leaf and manufactured 67,477lbs. of tobacco, 583,275 cigars, weighing 22,855lbs. and 585,000 cigarettes, or 1,316lbs.

POSTS AND TELEGRAPHS.

Post Offices.—Western Australia is splendidly equipped over its great area with all the modern facilities for receiving and despatching mails, cables, and telegrams. In 1889, there were 82 post offices in the Colony; in 1898, there were 171 offices that handled 24,081,430 letters, papers, etc., in all. The Colony entered the Postal Union in 1891, the charge on foreign letters being reduced from 6d. to $2\frac{1}{2}$d. per $\frac{1}{2}$oz. Newspapers within the Colony, under certain limitations, go free. The intercolonial postage is 2d. per $\frac{1}{2}$oz.

Money Orders.—The amount of money received and sent away annually under this head constitutes a large sum, and embraces transactions with 16 different countries, including Hong Kong, Singapore, and Mauritius. The number of money orders despatched has increased from 6,557 in 1889, covering £25,129, to 231,387 in 1898, of the value of £888,389, and, *per contra*, the orders received run from 3,227 for £10,410 in 1889 to 80,784 for £330,597 in 1898. In 1898, there were 20,771 less orders sent out of the Colony than in 1897, equal to £171,139; while, during the same periods, the amount of money sent into the Colony increased between 1897 and 1898 by 20,356 orders for £83,207. This gratifying result is due to the fact that the miners and others who came to spy out the land have got a hold, and instead of remitting their savings to their families elsewhere, are bringing their wives and families over to the land of their adoption and keeping the money in the Colony.

Telegraphs.—The Western Australian Telegraph System belongs exclusively to the Government, and is worked in connection with the Post Office. The number of telegraph stations has increased from 42, with 2,961 miles of line and 3,546 miles of wire, dealing with 197,587 messages received and sent in 1889, to 147 stations, with 5,886 miles of line and 8,660 miles of wire, dealing with a total of 1,178,928 telegrams and cables handled in 1898.

Cable communication is available from Western Australia to Europe, either direct by Roebuck Bay or by Adelaide and Port Darwin. Roebuck Bay, 2,491 miles from Eucla, on the South Australian border, is the station where the alternative cable of the Eastern Extension Cable Company from Banjowangie is landed. The distance *viâ* Roebuck Bay is:—

Perth to Roebuck Bay	1,485	miles.
Roebuck Bay to Banjowangie	970	,,
Banjowangie to London	9,841	,,
	12,296	,,

The Bank of Australasia, Perth.

General Post Office, Perth.

And *viâ* Port Darwin :—

Perth to Eucla ...	...	1,006 miles.
Eucla to Adelaide ...	...	1,000 ,,
Adelaide to Port Darwin	...	2,134 ,,
Port Darwin to Banjowangie	...	1,150 ,,
Banjowangie to London	...	9,841 ,,
		15,131 ,,

TELEPHONES.—The Telephones have increased from 97 subscribers (including Government Departments) with 80 miles of wire in 1889, to 1,915 subscribers with 2,099 miles of wire in 1898.

EDUCATION.

The State System of Education in Western Australia is confined at present to Elementary Schools, the Secondary Schools being entirely in the hands of private establishments. The Perth High School, however, receives a Government subsidy; but it is not under the control or inspection of the Education Department, being governed by a Board appointed by the Governor in Council. In addition to three Scholarships of £50 a year each, tenable at Secondary Schools for two years, the State offers, annually, 10 Government Exhibitions, which are money prizes of £25 and £15, and 12 or more Bursaries of £10 each for competition amongst children attending Elementary Schools, to be held for a year at such schools.

Western Australia has no University, but examinations are held periodically in Perth, under the auspices of a committee appointed from the Adelaide University. The Christian Brothers have a branch College in Perth, and there is also a Scotch College, from both of which, as well as from the High School, boys are sent in for the Adelaide public examinations. There is also a private Girls' High School, and there are numbers of private establishments which do not undergo any Government examination. Under the latest Act dealing with compulsion, private schools will have to show that they are efficient, and for this purpose the Minister may insist upon inspection. It has not, however, at present been carried into operation, having only been passed at the end of last year.

STATE EDUCATION.

The general features of the State educational system of Western Australia may be set down briefly as follows:—The system is free and compulsory. The teaching in the Government Schools is secular, but half-an-hour is devoted to general religious teaching, which, by the Amendment Act, 1893, is classed under "secular" instruction. By the same Act ministers of religion are permitted, under certain regulations, to teach the children of their own denomination for half-an-hour during school hours.

The administration of State Education is in the hands of the Minister of Education, who is assisted by various District Boards, acting generally as Boards of Advice. For the year ending 31st December, 1899, the total expenditure was £62,028 7s. 2d.

Under the Education Acts, the Minister is empowered to spend a sum not exceeding £4 10s. per head of children attending the Government Schools.

Elementary Day Schools are divided into State Schools, Provisional Schools, Half-time Schools, House-to-house Schools, and Special Schools. A State School may be established in any locality where an average attendance of 20 children between the ages of 6 and 14 can be guaranteed, and Provisional Schools where an average of 10 can be maintained. Further, schools may be established where there are less than 10 children, and the grant then, if given, is £4 10s. per annum for each pupil in average daily attendance; the settlers or promoters being expected to supplement the grant so that the teacher receives not less than £60 per annum salary. In scattered settlements, where one central school is not feasible on account of the distance the children would have to travel, two Half-time Schools may be established under the charge of the teacher, who will give lessons in one school one portion of the week, and in the other during the remainder. Special schools are only so called for purposes of salary. They are established in places at a great distance from Perth, where regular visits from the Inspector cannot be held, as, for instance, in the North-West. Teachers in Special Schools may be paid at a higher rate than the ordinary scale fixed.

There were, on the 31st December, 1899, 125 State, 62 Provisional, 14 Half-time, and 4 House-to-house Schools in the Colony.

The number of children on the roll in the Government Schools for the week ending 31st December, 1899, was 16,033—viz., 8,606 boys, and 7,427 girls. The average attendance for the December quarter was 12,658.

There are also Evening Classes in Perth, Fremantle, and other parts of the Colony, in which, in addition to elementary subjects, certain technical and commercial subjects are taken. In Fremantle especially, technical classes have been held; for example, in Steam and Electricity, for apprentices and others from the Locomotive Workshops.

The Government has now appointed a Director of Technical Education; a chemical laboratory and furnaces for assaying are being fitted up, and classes, both day and evening, are being opened in these subjects.

In addition to carpentry classes in the Evening School at Perth, a scheme of manual training and the use of tools in wood

Church of England Cathedral, Perth.

Roman Catholic Cathedral, Perth.

has been in operation for the last two years for the day scholars, and some hundreds of boys have been instructed.

The curriculum in the day schools is liberal, comprising, besides the three elementary subjects, Drawing, English, Geography, History, Drill, Music, Elementary Agriculture for boys, and Needlework for girls; and in the higher standards specific subjects from the following list may be taken:—Algebra, Euclid, Mensuration, Latin, Mechanics, French, Physiology, Botany, Chemistry, Domestic Economy, and Shorthand.

In the infants' departments there is a considerable amount of Kindergarten teaching; special instructresses having recently been imported from England.

A cookery centre has been built for girls in Perth.

The present Minister of Education is the Hon. George Randell. The permanent head of the Department is Mr. Cyril Jackson, M.A.

RELIGION.

Clergy and Churches.—According to latest available statistics, the clergy, ministers, etc., number 182; of whom 37. belong to the Anglican Church, 34 to the Roman Catholic Church, 12, to the Presbyterian Church, 36 to the Wesleyan Methodist Church, nine to the Congregational Church, four to the Baptist Church, two to the Church of Christ, 40 to the Salvation Army, two to the Seventh Day Adventists, five to the Hebrew Congregation, and one Mahommedan. Besides this, there are 435 officials connected with the various sects, who, without being regularly ordained, are styled lay readers, local preachers, mission agents, etc., and who help to swell the ranks of religious instructors in the Colony.

The buildings used for public worship throughout Western Australia number 472, of which 201 are regular churches and chapels, and 271 schools and other buildings. Seating accommodation is provided for 54,000 persons, the estimated number of those who attend Sabbath services being 46,000. No less than 47,000 services are performed during the year. Of the whole number of buildings used for public worship, 168 belong the Anglican Church, 82 to the Roman Catholics, 15 to the Presbyterians, 118 to the Wesleyan Methodists, 37 to the Congregationalists, eight to the Baptists, five to the Church of Christ, 25 to the Salvation Army, one to the Seventh Day Adventists, seven to the Jews, and six to the Mahommedans. As complete information is not available in regard to the above enumerations, these figures may be taken to express the minimum.

Sunday Schools.—The Colony possesses 203 Sunday schools, employing 1,032 teachers, 442 male and 590 female.

PRICES.

Highest and Lowest Wholesale Prices at Perth of the principal kinds of Agricultural, Orchard, and Farmyard Produce during 1899. *

Description of Produce.	Min.	Max.
	£ s. d.	£ s. d.
GRAIN—		
Wheat, per bushel	0 3 0	0 5 0
Oats, per bushel	0 2 7	0 3 6
Barley, per bushel	0 3 0	0 5 6
Maize, per bushel	0 4 6	0 5 6
MILL PRODUCE—		
Flour, Roller, per ton ...	7 15 0	11 10 0
Bran, per ton...	5 10 0	7 0 0
Pollard, per ton	5 10 0	7 5 0
FARM PRODUCE—		
Hay, per ton	2 10 0	3 12 6
Chaff, per ton	2 10 0	5 5 0
Potatoes, per ton	2 0 0	10 0 0
Onions, local, per ton ...	5 10 0	11 0 0
Do. imported	6 10 0	10 10 0
DAIRY PRODUCE—		
Butter, local, per lb. ...	0 0 9	0 2 2
Do. imported, per lb. ...	0 1 0	0 1 4
Bacon, per lb.	0 0 9	0 0 11½
Hams, per lb	0 1 1	0 1 3
Eggs, local, per doz. ...	0 1 0	0 2 10
Do. imported, per doz. ...	0 1 0	0 1 11
Cheese, per lb.	0 0 6	0 0 9
Lard, per lb.	0 0 9	0 0 10
POULTRY—		
Fowls, per pair	0 4 0	0 8 0
Ducks, per pair	0 4 6	0 8 6
Geese, per pair	0 9 0	0 16 0
Turkeys, Goblers, per pair	0 14 0	1 10 0
Do. Hens, per pair ...	0 8 0	1 1 0
FRUIT—		
Apples, eating, per lb. ...	0 0 3¼	0 1 6
Do. cooking, per lb. ...	0 0 2	0 0 8
Apricots, local, per dozen ..	0 0 8	0 1 8
Bananas, per case	0 15 0	1 15 0
Cherries, per case	0 15 0	1 12 0
Cape Gooseberries, per lb.	0 0 2½	0 0 8

Description of Produce.	Min.	Max.
	s. d.	s. d.
Figs, fresh, per dozen ...	0 2	0 6
Grapes, per lb.	0 1	0 7
Loquats, per lb.	0 3	0 7
Lemons, local, per dozen ...	0 6	1 7
Do. imported, Italian, per double case	15 0	40 0
Do. imported, Eastern, per case	8 0	12 0
Nectarines, per dozen	0 3	1 0
Oranges, local, per dozen ...	0 9	2 10
Do. imported, per case ...	15 0	33 0
Pears, eating, per lb.	0 2½	1 0
Do. cooking, per lb.	0 2	0 6
Peaches, per dozen	0 6	2 6
Plums; local, per lb.	0 1	0 5
Passion Fruit, per case ...	11 0	15 0
Do. per dozen ...	0 2	0 7
Quinces, per lb.	0 1	0 3½
Strawberries, per lb.	1 0	2 6
VEGETABLES—		
Beans, Broad, per lb.	0 0½	0 2
Do. French, per lb. ...	0 0½	0 4
Beetroot, per dozen bunches	0 9	3 0
Cabbage, per cwt.	2 0	18 0
Cauliflowers, per dozen ...	4 0	15 0
Carrots, per dozen bunches ...	0 4	2 0
Do. per cwt....	3 0	9 6
Celery, per dozen sticks ...	0 6	3 0
Cucumbers, per dozen	1 0	12 0
Lettuces, per dozen	0 3	1 0
Marrows, per dozen	1 0	4 0
Melons, Rock, per dozen ...	3 0	10 0
Do. Water, per dozen ...	2 6	12 0
Pumpkins, per cwt.	2 0	8 0
Peas, Green, per lb.	0 0½	0 6
Parsnips, per dozen bunches ...	1 0	2 6
Rhubarb, per lb....	0 1	0 6
Spring Onions, per dozen bunches	0 3	1 0
Tomatoes, per lb.	0 0½	0 6
Turnips, per dozen bunches ..	0 6	2 0
Do. Swedes, per cwt. ...	4 6	7 0

* This table has been compiled from the weekly reports of the leading Produce Commission Merchants in Perth.

Wesley Church, Perth.

Congregational Church, Perth.

FLORA AND FAUNA.

(By Richard Helms, Biologist to the Department of Agriculture.)

The Flora.—From a scientific point of view, as well as a utilitarian standpoint, the natural features of Western Australia offer much of interest. In the limited space allotted to these pages it is impossible to do full justice to the subject, as it is scarcely sufficient for more than a general sketch of the leading characteristics, and, consequently, much that is interesting may have to be omitted, or only hurriedly be touched upon.

The Western portion of this Continent has been designated the Autochtonous area, specially so in regard to the flora and fauna of Australia, owing to its antiquity having been retained in almost undisturbed originality. This is more particularly manifested by the peculiarity of its flora, which has more or less impressed its characteristic upon the whole Continent, an invasion of the predominating plants, it is considered, to have come from the West. Looking even superficially at the vegetation, the abundance of proteacean species at once attracts attention, and stamp the country as peculiar. Besides these, many other plants contribute towards individualising, so to say, the appearance of this remarkable land, which differs in such a degree from all other countries, that almost everything appears novel at first sight, and on critical examination this becomes still more apparent.

A strikingly novel appearance is imparted to the landscape by the many grass-trees; one, a *Xanthorrhœa*, with an enormous erect flower-spike rising from its apex, and another, the unique *Kingia*, whose much shorter spikes surround the head of the tree like a crown. Over every scantily forested plain, valley, or slope, these curious trees are conspicuously in evidence. In the coastal districts the palm-like *Macrozamia* occurs abundantly, where it is often found intermixed with the grass-trees, or in shady situations predominates, attracting attention by its deep-green fronds. However, the often bulky, and in many districts extraordinarily lofty *Eucalypts*, distributed as they are throughout the country and forming more or less compact forests over enormous tracts, give the land its typical Australian aspect.

But whoever passes through the country from July to January must be struck with the abundance of flowers that everywhere embellish the surface of the ground. This floral display reaches its grandest perfection in September and October. More than 3,600 flowering plants occur in Western Australia, and the profusion of many species, as well as the varied and most brilliant colours that meet one's eyes in a day's walk, would be scarcely credited by anyone who had not been fortunate enough to witness this pheno-

menal display. That Western Australia is not surpassed by any other land in the production of an indigenous floral beauty is a fact which cannot be disputed.

Only a few of the more striking can be referred to. Among such, the curious Kangaroo Paws *(Anigozanthos)* deserve mentioning on account of their deep-coloured flowers being covered with a plush-like tomentum. *A. Manglesii* is one of the most attractive of these. The stalk as far as the raceme, and particularly the swollen base of each flower, is of a rich crimson, whilst the curved tubular flowers, which often reach a length of more than 2½ inches, are of a darkish intensely green colour. Another *(A. viridis)* has quite green flowers arranged as with the preceding species in a single terminal raceme on each stalk. A very attractive species also is *A. fuliginosus* with a dichotomously-branched inflorescence and flowers, the lower half of which are clothed in a black velvety pile whilst the other part is yellow. These unique plants are indigenous to Western Australia only, together with several allied genera, of which the largest *(Conostylis)* is widely distributed over the whole length of the Darling Range and along its slopes. The lovely blue *Leschenaultias* and their allies, the feathery flowers of several species of *Thysanotus*, the varied coloured species of *Stylideæ*, several of which cover large patches of ground carpet-like whilst blooming profusely, a number of *Epacridæ*, shrub-like *Myrtaceæ*, *Grevilleas*, *Hakeas* and the many differently coloured *Leguminosæ*, amongst which some low-growing *Acacias* during the season deck large areas in golden yellow, the different *Everlastings*, many terrestrial *Orchids* of which the "Spider Orchid" *(Caladenia Patersoni)* is a curious and well-known species, and other chaste flowers, are constantly charming the eyes of the botanist and scarcely fail to command the attention of even those whose taste for the beautiful has been left uncultivated. Mention must also be made of the handsome and well-known "Swan River Daisy" *(Brachycome iberidifolia)* with its cineraria-resembling flowers of a bluish-violet colour, which become during the early summer prominently noticeable over the extensive habitat of the plant. Another well-known plant is the Christmas Tree of the colonists, so named because it displays its brilliant orange-yellow flowers in greatest profusion about the middle and latter end of December, although it begins to flower from the middle of November and not entirely ceases till the end of January. In addition to its great floral beauty, it is also remarkable on account of its abnormal habit, being the only species of the order *Loranthaceæ* that is not parasitic. *Nuytsia floribunda*, as the tree is called, grows to a height of sometimes over 25 feet, and may have a trunk of over two feet in diameter. It is confined to the South-Western portion of Western Australia, but in that part has a wide distribution, showing up conspicuously over the landscape when covered with its masses of bright flowers, as if all in a blaze. The gaudily flowering *Eucalyptus ficifolia*, restricted to Western Australia, like most of the species belonging to this genus found here, has not a wide distribution, being confined to the humid area of the far South-West. But its lustrous crimson flowers make it the handsomest

St. George's Terrace, Perth, looking West.

St. George's Terrace, Perth, looking East.

amongst its relatives, and consequently it is much sought after as an ornamental tree, for which purpose it is admirably adapted, as it rarely grows over 30 feet high, quickly develops, and flowers at an early age.

Epitomising the salient characteristics of the Western Australian vegetation, we find that 400 species *Proteaceæ*, of the approximately 600 found in Australia, occur in Western Australia, the greater number of which are peculiar to this region. The large genus *Dryandra* and the genera *Simsia* and *Synaphea* are found in no other part of Australia; and the genera *Petrophila*, *Isopogon*, *Adenanthos*, *Conospermum*, and *Lambertia* include very few species found in the Eastern provinces; whilst also two-thirds of the prominent genera *Grevillea*, *Hakea*, and *Banksia* are confined within its limits.

Leguminosæ, the largest order of Australian plants, containing about 1,100 species, are represented by upwards of 500 species, 120 of which are acacias. Many genera, as *Brachysema*, *Oxylobium*, *Chorizema*, *Gastrolobium*, *Jacksonia*, *Daviesia*, and others are almost entirely or predominatingly Western Australian.

Amongst *Myrtaceæ* the proportion is still greater, 390 of 670 Australian species being found here. Of these the genera *Beaufortia*, *Hypocalymma*, *Verticordia*, and *Calothamnus* are endemic, and *Darwinea*, *Calycothrix*, *Thryptomene*, *Baeckea*, and *Melaleuca* contain to the greater extent species peculiar to Western Australia.

Similarly we find the *Epacrideæ* represented; 158 of the 275 known Australian species are found in Western Australia, and eight genera are peculiar to this region.

The order of *Myoporinæ* contains about 76 species, and of these 49 occur in Western Australia, *Eremophila* forming a predominating genus.

Amongst the 24 *Casuarinæ* 15 are recorded, and of these 10 are endemic to Western Australia.

Candolleaceæ (*Stylideæ*) are to the greater extent confined to the Westernmost region, 73 of the 97 recorded Australian species occurring here.

The occurrence of *Droseraceæ* is equally interesting, as 34 of the 47 known species are found in Western Australia, including the most robust and remarkable forms; and with the exception of four none occur elsewhere.

This interesting comparison might be continued still further, but I think enough has been said on the subject, and I will only mention the distribution of the *Salsolaceæ*, these world-famed Australian forage plants, of which 61 of the 111 described species have been observed in Western Australia, as this links the mainly scientific features of the flora hitherto discussed to the principle of utilitarinism.

Indigenous forage plants are fairly abundant in this country, producing, in many districts, very favourable depasturing facilities

for rearing and fattening sheep and cattle. A proof of this is the steady increase of live stock in the Colony as demonstrated by the statistical tables. But in this direction the Western Australian vegetation does not possess any economic superiority over that found in other portions of Australia, and in certain localities the grazier is placed at a disadvantage through the occurrence of dangerous poison plants.

In the extensive forests of the country a natural wealth has been stored that is not surpassed in any other portion of Australia, on account of the quality of their products. A large proportion of the Western Australian trees produce timber of extraordinary durability under the most trying conditions, a few amongst them being practically indestructible by ordinary use. The foremost position amongst these must be allotted to the Jarrah (*Eucalyptus marginata*), the durability of which is becoming world-famed. This tree covers large areas, often without much intermixture of other species, and predominates throughout the South-Western region. Although not one of the loftiest of Eucalypts, it nevertheless reaches a height of over 100 feet, with a diameter of over five feet. Many trees furnish a trunk of over 50 feet, over $2\frac{1}{2}$ feet through, fit for cutting into building timber. As a proof of its durability a few instances may be quoted:—Piles driven for bridges more than 50 years ago, have repeatedly been drawn and found perfectly sound. In the Department of Agriculture a section of a piece of timber is kept that must have been buried for upwards of 400 years, and is still quite sound. This piece was covered by four feet of soil between the roots of a jarrah tree over four feet in diameter, and as the jarrah is a slow grower, this tree could not have been much short of the age quoted. Another quality of this timber, the value of which can scarcely be over-rated, is its immunity against the attack of Termites, as well as the Teredo and other marine borers. At the moment of writing this, Captain G. R. Beddoes gave me a call, and we at once discussed the quality of jarrah regarding its resistance of marine borers, as I know he has had considerable experience in this matter. He told me that certain piles used by him for marine structures at Natal, where he first became acquainted with jarrah timber, were bored by the Toredo, whilst the greater portion were not. He made the same observations at the Abrolhos Islands, where he used piles of other timber. He has from these observations formed the opinion that the tree must be cut when in sap, in order to resist marine borers, or rather, to put it properly, that then the taste of the timber is objectionable to them. It is evident that the hardness of the timber, although considerable, does not protect it from the attack, because marine borers go through much harder wood. For the same reason it is likely that Termites do not attack it, because certain species in the Northern Territory of South Australia are known to have perforated the lead flushings under the eaves of roofs. Railway sleepers in use for 18 years are still perfectly sound, and piles used in marine structures have stood much longer without protection of copper. These properties qualify the timber

for such uses above any other, and make it sought for in all tropical countries where these predacious creatures abound. The breaking strain is higher than that of oak.

Besides these exemplary qualities it is a very handsome timber, and adapted to all kinds of furniture and fittings in buildings. When polished, its colour varies from yellowish brown to almost black, a dark brown being the predominating shade; it has acquired locally the name of Mahogany. It yields a large quantity of excellent charcoal.

Next of importance to the jarrah is the Karri (*E. diversicolor*). This is a giant tree, yielding immense quantities of large-sized timber, pieces of 100ft. in length and two feet square having been exported. Trees with a diameter of 6ft. at the base and 80ft. to 100ft. to the first branch are not uncommon, and exceptionally fine specimens, having a circumference of between 20ft. and 30ft., and an extreme height of upwards of 300ft. are met with. The largest measured tree is 34ft. in circumference three feet from the ground, 160ft. to the first branch, 14ft. in circumference at this point, and 242ft. in extreme height. The valuable Karri is confined to the humid South-Western portion of the Colony, where it extends over an area of from 1,600 to 1,800 square miles. The breaking strain of its timber is higher than that of jarrah, and two-thirds more than of oak. This excellent quality, together with the large faultless pieces obtainable, makes the timber highly valuable; because for structures that have to carry great weights it cannot be surpassed. In colour and grain it is much the same as jarrah, and so they are difficult to distinguish when sawn.

Another highly useful timber is obtained from the Tuart (*E. gomphocephala*), a handsome tree of considerable dimensions, although not reaching those of the karri and the jarrah. It is considered the strongest, heaviest, and toughest timber in Western Australia, and is also very durable. It is impossible to split this wood with ordinary tools when it is seasoned, nor does the weather affect it when once it is dry. Its strength and toughness qualify it particularly for wagon work, shafts, naves, and felloes made from it being almost indestructible. The habitation of the Tuart is the undulating limestone formation fringing the Southern portion of the Western coast line.

Besides these trees possessing phenomenally fine qualities, there are found amongst the Eucalypts and other families many other trees yielding timber of more than ordinary value. Nearly all the Western Australian gum trees produce timber of great durability, as has been proved by a number of recorded evidences of their long resistance against decay under trying tests. The following three deserve yet to be mentioned, two of which grow over large areas to the East of the Darling Range, and are extensively used for structures of every description: The Wandoo or White Gum *(E. redunca)*, the Blackbutt *(E. patens)*, and the York Gum *(E. loxophleba)*. The first two produce a light coloured timber, and the last-mentioned a brown, which equals in toughness the tuart and,

being lighter, it is particularly well adapted for carriage work, and is much sought after beyond the Colony for the construction of light vehicles. The tree mainly occupies an extensive belt of valuable agricultural land. It has derived its vernacular name from being abundant in the York district, which is one of the oldest settlements of Western Australia, and noted for its fertile soil. Blackbutt grows only in rich soil, and is mostly confined to valleys, its presence always indicating good agricultural land. The timber is characterised by toughness and its resistance to fire, burning with difficulty even when quite dry.

To give a complete list of the Western Australian timbers possessing extraordinary resistance against decay is not intended; only one more endemic species will be mentioned, as it possesses this valuable characteristic to a surprising degree. *Acacia acuminata* is the tree referred to; it is popularly called Raspberry Jam from the pleasant odour of its wood; grows in the drier parts to the East of the Darling Range, and in the North. Unfortunately it does not develop to great dimensions, its extreme height rarely exceeding 25 feet, and its trunk a diameter of one foot and ten feet in length; its use is therefore restricted mainly to outbuildings and fence posts, for which purpose, however, it cannot be surpassed, as termites do not touch it. I have seen miles of wire fences, the posts of which did not measure more than three inches through, that have stood for over 40 years, and are still as sound as ever.

Besides such timbers as those mentioned, which are valued mainly for their strength, there are also found a number admirably suited for the manufacture of furniture. The Casuarinas, or Sheaoaks, as they are better known, are all well adapted for this purpose. They are light and mostly handsomely grained or mottled. *Casuarina Fraseriana* is the largest of these, and, on account of its size, used in preference to the other species. Amongst the arboreal Banksias, several species grow large enough to produce good boards, their mottled nature and markings making them always attractive when used for furniture or panels in wainscotings and for other decorative purposes.

Santalum cygnorum, the Sandalwood tree, grows over a very extensive area in the Eastern parts of the Colony and extends into the arid region. Although only a small tree, and never found to predominate in any locality, but generally growing singly between other forest trees, it nevertheless has been for a number of years a source of income to the settlers, as nearly the whole of it, from the root to the branches, is marketable. Large quantities are annually exported, mainly to China; and for a number of years the valuable oil was extracted in the Colony, but at present this industry is not followed.

From nearly all Eucalypts volatile aromatic oil of considerable medicinal value can be extracted by the distillation of their young leaves; and the foliage of the Willow Myrtle, or Peppermint tree (*Agonis flexuosa*), yields a highly scented oil possessed of antiseptic and other qualities. The wood of the Raspberry Jam also contains a

pleasant odoriferous oil suitable for perfumery; and many of the richly-scented flowers yield essential oils. Hitherto only the scented Boronia (*B. megastigma*) has been utilised to a limited extent amongst the flowers, whilst eucalyptus oil is produced in considerable quantities. There is plenty of scope for the expansion of the manufacture of these endemic productions.

THE FAUNA.

INVERTEBRATA.—According to the specific profusion of plant life found in Western Australia, and taking the favourable climate into consideration, it might be expected that the variety of animals would be correspondingly large, and that especially the lower forms would be abundant and much diversified. But this conjecture, although not entirely falsified by fact, is nevertheless much shaken under close examination. It is true that the invertebrate fauna is considerably varied, and comprises many species peculiarly its own, yet only a limited variety are met with in abundance. By far the greater proportion is of comparatively rare occurrence, and very many of these are very rare, and seemingly confined in many instances to special localities. Why, with the very diversified flora, insect life, as an instance, should not be equally abundant, is a problem difficult to solve, but, from the scarcity of many species and their circumscribed habitats, it would appear that the fauna has been undergoing for a considerable period a natural decay.

It is difficult even to approximately estimate the number of species, for the following reasons:—In the first place, no extensive collection exists in any of the public institutions of Western Australia; secondly, the record of described species is scattered over a number of publications in various European countries; and thirdly, because the country has not been thoroughly exploited yet, and has not been searched for animals as it has been for plants. Judging superficially from what is known, together with my own observations, I am of opinion that the fauna, taking all classes of invertebrates into consideration, falls considerably behind that of Europe in the number of species, although in the old country the cultivation of the greater portion of the soil, and other circumstances, have been the cause of exterminating an enormous proportion of the indigenous animals. With the exception of *Orthoptera*, of which the number of Western Australian species undoubtedly surpasses that of Europe, no other order of insects is numerically equal to any European species, and amongst the *Coleoptera* probably only the family *Curculionidæ* may contain as many.

Owing to the enormous surface still entirely in its natural state, as well as the little interfered with areas surrounding the settlements, together with the peculiarly variable quality of the land, which is seldom found to be uniform over extensive tracts in that part of the country best adapted for agronomic industries, and compels the cultivator of the soil to leave portions practically undisturbed, there will for a long time to come be a profitable

field of investigation to naturalists left in Western Australia, because the interference of man will not be seriously felt as regards the lower animals, much as it has already impressed itself upon the higher life.

About *Vermes* little or nothing is known, and amongst the *Arthropoda*, *Crustaceans*, *Spiders*, *Scorpions*, and *Centipedes* few species only have received more than superficial attention. Of crustaceans some remarkable forms are met with on land and in stagnant water, while the saline portion of the rivers swarm with several species of crabs. Amongst the spiders also a large variety of curious forms occur: and amongst the *Myriapoda* the unique genus *Peripatus* has a representative.

Coming to the *Insecta*, the orders *Hemiptera*, *Heteroptera*, as well as *Homoptera*, are well represented by a large number of species and include many remarkable varieties and striking examples. A considerable number of *Coccidæ* and *Psyllidæ* furnish prolific species, and the peculiar and limited Australian genus of gall-forming insects (*Apiomorpha*) belonging to this order, is represented by several species not found elsewhere, besides a few having a wider distribution. Of *Callipapus*, another curious genus, several species are found. The males of these insects are known as "Paradise Flies" on account of the bunch of silky filaments attached to the distal joint of their abdomen, resembling a miniature tail of the great paradise bird. They are very graceful and do not at all resemble their clumsy and obese mates, which are always more or less enclosed in a white mealy or filamentous waxy tegument.

Orthoptera occur in abundance, and include many striking forms. Some remarkable *Locustidæ* of large size have to be counted with the rarer species, and amongst the *Phasmidæ* some gigantic species are met with. The largest of these, a handsome green species of *Podacanthus*, with vitrous underwings, is seven inches long, and has an expanse of wings of over ten inches. Another species of the same genus, also green and with pink underwings, is sometimes over six inches across the extended wings. A species of *Dicera*, upwards of ten inches long, is grey, and has its proportionately short membraneous wings mottled with purple blotches. Many of the *Acridiidae* have coloured underwings, and this family, being the largest, includes a considerable variety of shapes and colour. Of *Blattidæ* a fair number are met with, some of which are large-sized, and other have a metallic or bronze coating.

Neuroptera are scantily represented, but a few handsome species occur amongst the *Libellulidæ*. The otherwise limited family, *Myrmeleontidæ*, seem to be fairly numerous in species, and of the different families of *Trichoptera* species may often be noticed flying at night towards lighted lamps. The remarkable genus *Nemoptera* is also found in Western Australia. A handsome species was sent by Governor Hutt to England in 1847, and was named *Nemoptera Huttii*. Another species was obtained by me near Nannine, and is deposited in the South Australian Museum. *Termitidæ* are abundant throughout the country. They are the

most serious indigenous pest found in Western Australia, and liable to do great damage to wooden structures other than those erected of jarrah.

Diptera are numerous, and many species occur in multitudes. The common house fly appears to outnumber all other flies put together, and there is probably no other country where they appear in such incredible swarms as they do over the greater part of the Colony. This insect is an annoyance to man and beast everywhere, whilst mosquitoes, on the other hand, are plentiful only near rivers and swamps. Besides *Muscidae*, which probably is everywhere the largest family, all other sections of the order appear to be represented. Some of the Gad Flies *(Tabanidæ)* are very large, and some gigantic species of *Asilidæ*, measuring over 1¼ inch in length, are strong enough to carry grasshoppers scarcely less than their own weight. *Tipulidæ* are not numerous, and of parasitic forms some *Nycteribiidæ* are the only ones known to me.

Lepidoptera.—The paucity of Butterflies is a remarkable feature of the Western Australian fauna. Next to New Zealand, whence only eight or nine species are known, Western Australia is the country poorest in *Rhophalocera*. Scarcely more than 20 species are known, and as they are the insects attracting most attention, being brightly coloured and flying during the day, it is not likely that many are left undiscovered. The commonest, besides, are widely distributed species and well known. None have very gaudy colours.

Junonia vellida, which is found throughout the Continent, is the commonest species, and next frequently *Pyrameis Kershawi*, *P. ita* and *Danais affinis* are seen. These are found throughout the whole of Western Australia, but never in large numbers. In the coastal districts the widely distributed *Heteronympha Doubledayi* and *Xenia Klugii* are most frequently seen, but occur also in many other parts. Some species of *Lycænida* are occasionally met with in considerable numbers, but they are not so widely distributed as the previously mentioned species. A few *Hesperiidæ* occur, and two species of *Delias* are known.

Moths, on the other hand, are more numerous. Amongst them a few species, of which the larvæ are found boring in wood, are very large, one of them measuring at times seven inches across the expanded wings, whilst other species of the group nearly approach this dimension. Besides these, some interesting *Bombicidæ* of considerable size are met with, as well as smaller species, and several *Psychidæ*. *Noctuidæ* are common, and of all moths occur in greatest abundance; and amongst the *Microlepidoptera* some very handsome species are met with.

Coleoptera are the best represented in this country. Nearly all families found in other parts of Australia are found here, and in some the species are numerous. *Curculionidæ* appear to be the most numerous of any, and although the greater number are of small or moderate size, several large species also occur in this family.

One group of it, the *Amycterini*, is numerous, and the species thereof mostly prominent, and to some extent characterises the beetle fauna. Amongst the *Buprestidæ* some uncommon forms of *Stigmodera*, the commonest and almost exclusively Australian genus of the family, are found, as well as the largest known species, *S. heros*. Besides these handsome beetles some other bright-coloured species are found amongst the *Lamellicornia*, *Phytophaga*, and *Malacodermi*. None of the groups of *Adephaga*, *Longicornia*, or *Brachelytra* are very numerous. A few beetles exhibit strong sculpturing on the elytra, as for instance a remarkably robust *Trox*, and attractive structural characteristics occur in others, such as the spinous processes of some *Catasarci* and *Amycteri*, or the developments indicating the males of some *Scarabacidæ*. A striking structural development is found in the genus *Helacus*, the species of which have an extended process of the elytra considerably reflexed, and in some of them reaching round the head. On the whole, however, such structural and other peculiarities are not abnormally frequent.

Hymenoptera are well represented, but they have not been studied much. Ants are numerous, and occur in large congregations, but not to the same extent as in Eastern Australia. Amongst other gregarious species of the order, a small stingless bee deserves mentioning. It builds its nest in the pipes of hollowed branches, making very delicate ovate cells for storing honey and rearing its brood. Some powerful *Vespidæ*, *Crabronidiæ*, and *Pompilidæ* are met with, and *Ichneumonidæ* are frequently seen. Many of the minute gall-making and parasitic species are common and widely distributed.

Land and freshwater *Mollusca* are sparsely distributed, and only few species are known, but these have an extensive distribution. *Bulimus melo* is the commonest, and in the coastal districts is frequently met with. *Bulimus dux*, a large species with a stout shell of nearly two inches, is met with only in the Southern district, but extends like the others into the arid regions. (Dead specimens were found by me in the Fraser Range.) *Helix perinflata* is also remarkable for its wide distribution over the most arid portion of Australia, extending right through the Victoria Desert into South Australia. The extreme South-Western very humid portions, which scientifically are scarcely known, are likely to harbour some unknown species, as there the natural conditions are favourable for these animals. The swamps contain a few species of *Limnæidæ*, and in some rivers a *Unio* is found. The littoral and marine fauna is rich.

Vertebrata.

Fishes.—Owing to the smallness of the rivers the true freshwater fishes are few and insignificant, and therefore of no importance except scientifically, but from that standpoint they have been neglected hitherto. In the expanding estuaries on the other hand, a number of fishes occur abundantly during the greater part of the year, as food is plentiful for them there, and many species enter

Barrack Street, Perth.

Hay Street, Perth.

periodically in large numbers to spawn. The variety of fishes along the coast is considerable and includes a number of very palatable species.

Amphibia.—On the Western side of the Darling Range as far as the sea, where swamps and small lakes are not infrequently met with, frogs are found occasionally in considerable numbers. On the Eastern side of the range they occur more sparingly and become rare towards the arid portions of the country. Upwards of a dozen species have been recorded, the greater number of which have a wide distribution.

Reptilia.—A long-necked turtle, with a carapace of about nine to ten inches, is frequent in the saline portions of rivers.

Only few of the true serpents are endemic. The greater number of those found in Western Australia have an extensive distribution over the Australian continents. None occurs in large numbers, not even in places apparently suiting their habits, and over the greater portion of the Colony snakes are rare. The largest is the well-known innocuous Carpet Snake (*Morelia variegata*), which has been recorded from widely separated places, but does not seem to be universally distributed. Of the venomous species, the Brown Snake (*Dimenia superciliosa*), the Brown-banded or Tiger Snake (*Hoplocephalus curtus*), and the Ringed Snake (*Vermicella annulata*) are the most frequently seen, and altogether about a dozen venomous, besides four or five harmless, snakes have hitherto been enumerated. Amongst the *Typhlopidæ* several very interesting species occur; these much resemble snakes; some of them may probably not have been described yet. Lizards are abundant, and include some very remarkable forms. The so-called Mountain Devil (*Moloch horridus*) is the most conspicuous amongst them. Its podgy shape and the spinose tubercles covering its head, body, and tail give the animal a terrifying appearance, but in reality it is the most harmless and defenceless creature imaginable. Seen in the sun, its reddish-brown colour, irregularly beaded and spotted with yellow and green, may be called bright and attractive, but chameleon-like, it can accommodate these tints according to surroundings, and if placed in a darkish place it soon assumes a grey coat. Why this remarkable lizard should have been called "mountain devil" is difficult to conceive, as it is not met with in mountainous country, its habitat being the drier portions to the East of the Darling Range, extending far inland over nearly the whole elevated plateau of Central Australia. Some species of *Egernia* are remarkable for their flattened and spinous tails, and the rarer *Diplodactyli* for their triangular tails and weak legs. One of the most widely distributed is the stumpy tail or shingle back (*Trachysaurus rugosus*), which Dampier mentioned. The Western variety of this species is blackish with irregular red and whitish spots, differing in colour from the Eastern variety, which is of a uniformly fulvous colour. This easily-caught lizard makes a common dish for the blacks, and is, when properly grilled, a delicious morsel, only surpassed by the more fleshy *varanus*. Of

this genus several species are found in Western Australia, the largest of which (*Varanus giganteus*) sometimes measures over six feet. *Amphiboluri* and *Lygosomæ* are abundant in nearly all parts of the country.

BIRDS.—The avifauna of Western Australia is fairly rich in species, but their numbers about the inhabited portions have suffered much through altered conditions. Besides being pursued by men, the birds have had additional enemies introduced in the shape of the domesticated dog and the cat. In no country besides New Zealand, where the birds prior to the advent of colonisation knew no terrestrial enemy, and consequently were ignorant of danger from such, and so easily approachable, have I observed such a decadence of the native avifauna to have been produced through the domesticated cat as in Western Australia. The traces of feral cats have been met with by me as far into the interior as the border of South Australia, and in certain parts of this Colony they are so common that they are frequently used for food by the blacks. Large numbers of birds are rarely met with, except occasionally ducks or flocks of migratory birds and of parrots, who, nesting in the pipes of decaying limbs in high trees are thereby protected against many enemies.

Man has also done much towards the destruction of water birds. For instance, the emblematical bird of the Colony, which was first noted on, and gave the name to the Swan River, where it was found in large numbers by the Dutch navigators, became extinct on its historical river; within the last three years the Government has re-introduced it at considerable expense by rearing a number in a convenient enclosure, and has since let them out upon the river. These half-tame birds are now strictly protected, and soon large numbers will disport themselves on the broad reaches of their ancient habitat which furnishes them with an abundant supply of food.

The largest species is the widely distributed struthious emu. In its plumage it varies by blotched feathers from the Eastern variety, on account of which it is by some ornithologists considered a distinct species, and has received the name *Dromæus irroratus*. Others, however, and probably justly so, consider it merely a geographical variety of *D. Novæ-Hollandiæ*, the Eastern emu. Another widely distributed bird is the well-known Bustard *(Eupodotis Australis)*, which like the Mallee hen or Gnou *(Lipoa ocellata)*, also well known in Western Australia, is more particularly a dry climate bird, and, although occurring near the coast, lives over the whole sub-tropical portion of Australia, including the interior arid zone.

Several birds of prey are found. The largest of the hawks is the Wedge-tailed Eagle (*Uroaëtus audax*), and the smallest the Kestrel (*Cerchneis cenchroides*), whilst the Brown Hawk (*Hieradicea verigora*) is the commonest. There are also two or three species of owls, of which the More Pork (*Ninox boobook*) sounds this peculiar cry frequently at night, and is the best known.

The Crow (*Corone Australis*) is common throughout the country, but less gregarious here than in other parts of Australia, and amongst other useful birds of similar size may be mentioned the Magpies (*Gymnorhina tibicen* and *G. dorsalis*) and the frog-mouthed Podargus (*P. strigoides*).

By far the greater number of Western Australian birds are insect feeders, and consequently of great value to the agriculturist. Flycatchers for instance are represented by about a dozen species, and several species of Wrens and Robins occur. Among these small birds the brilliant Blue Wren (*Malurus splendens*), the Scarlet-breasted Robin (*Petrœca Campbelli*), and the minute Yellow-rumped Tit (*Acanthiza chrysorrhoa*) deserve mentioning for their handsome plumage. But, as might be expected, the brightest colours are found amongst the Parrots and Parrakeets, of which 32 species are recorded. Amongst them the Yellow-cheeked Parrakeet is one of the best known, and, on account of its call, is popularly known as the Twenty-eight. It is a handsome bird and an excellent whistler and talker when taught in captivity, but unfortunately, like a number of its congeners, it is rather fond of fruit, and becomes occasionally very mischievous in orchards. Black Cockatoos are met with frequently in smaller or larger flocks, as this bird, like all its allies, is gregarious The white-tailed species (*Calyptorhynchus baudini*) and the red-tailed (*C. stellatus*) are the best known. Large flocks of rose-breasted Gallahs (*Cacatua roseicapilla*) are often seen in a number of localities.

Along the coast bird life is abundant and rich in species. Large numbers congregate regularly on the different islands scattered within moderate distance from the shore. The small Penguin (*Eudyptula minor*) nests regularly on an island not far from Fremantle, which in consequence has received the name Penguin Island, and near Sharks Bay an island frequented during the breeding season by the Pelican (*Pelecanus conspicillatus*) is known as Pelican Island. A large number of the islands habitually visited by large flocks of sea-birds to breed on are covered with considerable quantities of guano, in respect of which the Abrolhos Islands, lying off Champion Bay, are the best known, having been exploited for this valuable manure for years past, and have still large quantities left upon them. On these islands bird life may be seen in incredible profusion; about 30 species of sea-birds inhabit the greater number of the low, flat, coral islets, or visit them regularly during the breeding season. Amongst them the Sooty Tern (*Sterna fuliginosa*), and the Noddy bird (*Anous stolidus*), are present always in tens of thousands, and by far outnumber all other species. To their habitual return in such enormous numbers the greater part of the accumulated guano is undoubtedly due. Two powerful birds of prey, the White-bellied Sea Eagle (*Haliaëtus leucogaster*), and the White-headed Osprey (*Pandion leucocephalus*), are also regularly found nesting on these islands.

Some birds are wanderers, and amongst those insect-eaters who prey on flying insects, several may be called migratory. With the

Cuckoos this is most noticeable, as they return at regular seasons; and next to these the Swallows, the Wood Swallows *(Artamus)* being represented by seven species. After the breeding season these birds are frequently seen in large flocks roving over the country. They are very gregarious at this time, and I think no other Australian passeriformes display a similar habit of keeping together in such large numbers.

There are nearly 340 birds known in Western Australia, and the foregoing is merely a haphazard selection from such as have been noted by me personally. Moreover, I have, as with the notes on other subjects, confined myself to the Southern, and more especially to the South-Western portion of the Colony, ignoring the Northern and the tropical regions. Much more of high interest might be added, did the allotted space permit it.

Mammalia.—Of the remarkable beaked and egg-laying mammals found in Australia, Western Australia possesses only one, namely, the Porcupine (*Echidna aculeata*); the Platypus (*Ornithorhynchus*) does not occur, nor have traces of its former existence as yet been discovered, although it is probable that in bygone epochs its habitat extended to the Western portions of the Continent.

Amongst the Marsupials the most interesting is undoubtedly the prettily banded Ant-eater (*Myrmecobius fasciatus*), whose home is the Southern half of the Colony, extending its habitat into South Australia, through the arid interior. Mr. G. Masters, the Curator of the McLeay Museum in Sydney, who has always been a keen observer, tells me that this animal has the habit of running rapidly round the ant-heaps, in order to entice the ants to leave their nests. He had frequently observed a narrow circular path round ant-heaps, the cause of which he could not understand, but one night, hearing a noise from his camp, he had the satisfaction of observing the animal in its method of alarming the ants, trotting round their nest, and later feeding upon them.

Of *Dasyuridæ*, the black-tailed Native Cat (*Dasyurus Geoffroyi*) is found, besides four species of the genus *Phascologale*, as well as two of *Sminthopsis*; but probably all the species of the minute animals forming the last genus are not known yet.

One of the remarkable Rabbit Bandicoots (*Peragale lagotis*) is found here, and also the Pig-footed Bandicoot (*Choeropus castanotus*); and the typical Striped Bandicoot (*Perameles Bougainvillei*) is apparently restricted to this portion of the Continent.

Amongst the *Phalangeridæ* the Common Opossum (*Trichosurus vulpecula*) is found abundantly, and the Ring-tailed Opossum (*Pseudochirus occidentalis*) also occurs in many localities. The Pigmy Flying-phalanger (*Acrobates pygmæus*) has been recorded from the Southern part of the Colony, and the lesser Flying Opossum (*Petaurus breviceps*) has been observed in widely apart localities of the Colony.

The minute Tarsipes (*Tarsipes rostratus*), a curious form indigenous only to Western Australia, has no relatives elsewhere.

Of *Macropodidæ* may be mentioned the Ruous Hare Wallaby (*Lagorchestes hirsutus*), the Banded Wallaby (*Lagostrophus fasciatus*), the Dama Wallaby (*Macropus Eugenii*), the Western Australian Rock Wallaby (*Petrogale lateralis*), the Black-gloved Wallaby (*Macropus irma*), and the Short-tailed Wallaby (*M. brachyurus*), as peculiar to Western Australia, whilst other species of wider distribution occur also, amongst them the great grey Kangaroo (*M. giganteus*). Four of the known Rat-kangaroos are met with in Western Australia.

Coming to the more highly specialised mammalia a few rodentia of the rat tribe have to be mentioned, amongst which the peculiarly Australian genus (*Hydromys*) is represented by the Sooty Beaver-Rat (*H. fuliginosus*). Four or five Bats and the Dingo complete the list of placental land mammals, but a seal (*Otaria Forsteri*) frequents the shores and adjacent islands, and Cetaceans occur along the coast.

Formerly whale fishing was a profitable pursuit on the coast, but the industry has entirely decayed owing to the scarcity of whales. The larger kangaroos are still plentiful in places. Their flesh is frequently offered for sale in towns, and although the number of these animals is getting less, owing to the settlement of the land, a considerable quantity of their skins is annually exported. Opossum and other skins are likewise exported and locally manufactured into rugs and other articles, the well-furred opossum skins, and next to them those of the Dama Wallaby, being well adapted for such purposes.

THE ABORIGINES.

The history of the aborigines of the Australian Continent, as shown by the records of the different colonies, prove that, as a race, the natives of Western Australia differ very little in type or physique from those of the other parts of Australia. The fact that ages before any civilised race saw the Australian shores the continent was inhabited by these primitive people, who lived nomadic lives, frequently raided the territory of adjoining tribes, and interchanged their women folk by the rough and ready method of capture, goes to prove that the incidence of territorial boundaries of each colony could have had no influence whatever in changing the native type. For, as the white man extends his possessions, the aborigines either go back into the interior or else die out under the influence of civilisation. The natural laws with regard to propagation and settlement are unalterable. The original occupiers of the soil, after a succession of ages, become, in type and custom, suited to the natural conditions of climate and soil. Like other animals, left alone they would go on and increase for all time as circumstances have formed them—a savage race organically fitted for their environments; but the moment the influence of a civilised race comes near them, their conditions of existence are changed, and extinction follows inevitably; not necessarily from rum or spirits of any kind, but simply from the fact that the influences surrounding civilised life are inconsistent with the continuance of uncivilised life. The aborigines therefore die out, having fulfilled their destiny, and the lands they occupied become the home of a civilised and industrious race. Yet while these stern facts are the lessons of everyday life, we find the Governments of the different colonies doing all they can for the amelioration of the condition and for the comfort of the aborigines, and no colony of the Australian group has taken more practical steps in this direction than the Colony of Western Australia. Associated with her earliest history we find the Government actively working for the protection of the native race, and issuing rations, blankets, and clothing to all and sundry. Even in the case of native criminals the humane work of the Government is manifest; and in the criminal settlement at Rottnest, which is set apart for the custody of those natives under sentence for various crimes, the comfort of the prisoners is secured. Passing away from the Government, we find the New Norcia Mission, established in the year 1846, conducted by its able and beneficent friend Bishop Salvado, under the auspices of the Benedictine Brotherhood, solely for the benefit of the aborigines. The natives there have a home, with food and clothing in plenty, while those who are in a condition to learn are taught handicrafts suitable to their abilities, and old and

young have the benefit of the instruction and paternal guidance of a Christian Father whose benevolence and singleness of purpose have stood the test of 54 years. Beyond the limits of the settled districts, another Mission under a kindred brotherhood, called the Trappist Mission, has been established in a remote section of the Colony—the far North-West—for the purpose of improving the condition of the aborigines, the work of which has been carried on in the face of danger to the self-sacrificing founders, yet with a determination and zeal that could only be exercised under Christian laws and Christian teaching. Other Missions were attempted in the same locality, but, after months of patient and prayerful working, the natives turned on the devotees and drove them from the place.

Apart from these praiseworthy efforts of the different religious denominations, it is satisfactory to find the Government and Legislature to the fore. Thousands of pounds have been voted and expended on behalf of the native races, and thousands of the aborigines have found their lot in life improved under the fostering care of the Government Board. The annual expenditure, sanctioned by the Government and the Legislature of the Colony, through the Aborigines Board, presided over by Mr. H. C. Prinsep, is a large one, and with it Western Australia is certainly doing her part to render happy and contented the last of a race whose existence and whose traditions are fast becoming a matter of history.

The following brief description of the physical and mental characteristics and social and domestic habits of the aborigines is taken from the " Western Australian Year Book," compiled by the Registrar General of the Colony, Mr. Malcolm A. C. Fraser, F.R.G.S., F.R.C. Inst. :—

Physical and Mental Characteristics.

Upon the whole the Australian Aborigines fall little short of the average Europeans in height, though far inferior to them in muscular development, the limbs being thin and excessively lean, combined sometimes with an abnormal corpulence. The bodies are delicately formed, and there is the usual total absence of calves to the legs, so characteristic of the dark races generally. The cranial formation, somewhat finer in the male than in the female sex, is, on the whole, narrow and lengthy, with high cheek-bones, the lower portion of the forehead about the brows projecting and the upper receding rapidly. The nose, narrow above, thereby causing the eyes to appear drawn together, becomes broader and somewhat squat further down. The ears are inclined a little forward, the mouth is large and unshapely, while the teeth are, on the contrary, fine and white, the upper row, like the upper lip, mostly overlapping the lower. The jawbone is contracted, the chin small, the complexion oftener coffee-brown than actually black. The pitch black hair is somewhat curly, without, however, being woolly, and when cleaned from the mass of grease and dirt that usually clogs it, is fine and glossy. The duration of life rarely exceeds 50 years.

The average height and girth of 50 aborigines measured at Rottnest Prison, where natives from all parts of the Colony are confined, were found to be $65\frac{1}{4}$ and $33\frac{1}{4}$ inches respectively.

Their intelligence and reflective faculties are, as a general rule, of a mean order; but surprising quickness of apprehension, a keen sense of the ridiculous, and a great talent for mimicry have been often exhibited by aborigines, and make them, in many instances, very good companions. Their females have been taught womanly accomplishments, and their men have learned and practised successfully mechanical trades; while in the Roman Catholic Mission at New Norcia, before referred to, they have proved good gardeners and agriculturists. Their perceptive faculties are very acute, and make them valuable as trackers; and as messengers, pearl-divers, shepherds, horsebreakers, stock-drivers, hunters, or at any employment requiring light manual labour, they have proved satisfactory and trustworthy. Nor, when instancing the use of aborigines to the white man, must the services of the natives who accompanied the early colonial explorers in some of their most arduous journeys, and proved almost indispensable to them, be forgotten.

Social Condition and Domestic Habits.

The social conditions of each tribe are governed by their food supply, and the facilities or difficulties of intercourse. Aborigines are conservative in their habits, refusing, for instance, to imitate the European methods of preparing food by boiling or stewing. The tribes, with few exceptions, are essentially nomads, having neither local habitations nor places of refuge, but roving only within the boundaries of that particular district, of the many into which the Colony is divided, occupied by them according to usage. In this they differ from other peoples of migratory habits, and still more in the fact that the time of visiting particular portions of their territory is generally regulated, so that their visit to that place occurs when the particular article of food for which it is noted will be plentiful or in season.

A curious custom, not peculiar to the Australian race, is that of the *kobong* or *totem*, by which that particular species of the animal or vegetable kingdom which is the distinguishing badge of a particular tribe is forbidden to the tribe as an article of food. Again, certain foods are forbidden to youths till they attain a certain age; but this custom does not seem to be connected with the taboo system mentioned above, and arises merely from utilitarian motives.

Food is obtained by hunting, fishing, or digging, and the supply is, as a rule, by no means scanty. Nor is the aborigines way of preparing food stereotyped or unsatisfactory. Though rude appliances are used, generally palatable and often really nice dishes are furnished. Thus some tribes prepare a fish for cooking by wrapping it in strips of a species of bark with a peculiarly flavoured juice, which exudes in the process of cooking, and being preserved by the wrappings, gives the fish a flavour which would satisfy the capricious gourmet.

Government House, Perth.

Government House. The Grounds.

In the matter of housing, their dwellings are of the most primitive description, taking generally the form of a break-wind composed of a few logs or thick branches covered with boughs or clay. In the Nor'-West the natives sleep in the open, and their fire forms the only camp they make. Little clothing is required in the case of the aborigines, and besides the girdle of yarn (noolban) the only garment used is the booka, a cloak made of kangaroo skins.

Their ornaments are few, the skin of a wild dog's tail worn across the upper part of the forehead, and a tuft of emu's or cockatoo's feathers tied round the arm or fastened in the hair being the most fashionable, while occasionally fur necklaces have been noticed by travellers. By inserting bones in the septum of the nose, and scarifying the breast and other parts, the face and figure, from a native point of view, is improved; while a kind of red ochre (whilgey) is used for colour ornamentation.

The women are very scantily clothed; their bookas being smaller than those of the men. Amongst other impedimenta they carry the coota or bag used when travelling for holding children, food, or other burdens, the grubbing stick or wanna, used for digging roots, and the lighted firestick of Banksia or Casuarina, which burns like touchwood, while in parts of the Colony the heart of the Xanthorrhœa, or grass tree, is used.

The aborigines display great cunning, perseverance, and agility in tracking, following and hunting game, furnished with such simple weapons as they possess, and have three different ways of hunting the kangaroo, as they have also three different ways of preparing its flesh when killed. Although rude, their hunting appliances are admirably adapted for the purposes to which they are put; the principal weapons being the boomerang (kyley), hatchet (kajou), knife (dabba), spear (gidgee), mero or wanner (throwing stick or board), and dowak (club). The different parts of their weapons are fastened with piriu (a kind of cement consisting of blackboy gum and charcoal), and their fishing nets are ingeniously made from the trioda or spinifex plant. The first named weapon, the kyley, is so constructed that, unless interfered with, it will assume a retrograde or lateral motion at the will of the person by whom it is thrown. This missile is not unique, as some imagine; a weapon almost identical with it having been used for hundreds of years in Abyssinia, and earlier still in ancient Egypt. Most of the hunting weapons already mentioned are, with slight alterations, also used in war; but in addition, the wondah, a wooden shield made of cork-wood, with an inward curve at the ends, and used for purposes of defence, is occasionally carried. An interesting collection of native weapons, including spear-heads, manufactured by the aborigines of the North-West from glass bottles and telegraph insulators, may be seen in the Western Australian Court. The tools used in cutting the glass are pieces of flint.

The chief amusements of the natives are spear throwing, dancing, singing, storytelling, and adorning themselves with paint, grease, and feathers; this last being almost wholly confined to the men.

THE GOLDFIELDS
OF WESTERN AUSTRALIA.

A COMPARISON AND A HISTORY.

(By E. W. Hine.)

In reviewing the auriferous history of Western Australia, or as it is more familiarly known, the "Golden West," we are confronted with three absolutely startling features—the marvellous development which has taken place during the past seven years; the enormous area over which the gold deposits have already been located, and the latent possibilities even within the prospected districts. The known gold-bearing region is twice as large as the Republic of France; reaching from Kimberley in the far North, to Norseman and Dundas in the South, a distance of over one thousand miles, while the width of this immense belt is fully three hundred miles.

It may safely be said that in point of area, of progress, and of production the Western Australian goldfields are practically without parallel in the history of mining. On many occasions the records of the Rand, the field which in some respects most closely approaches Western Australia, have been held to be unequalled; but output for output, and period for period of the operations the official figures award the palm to the Cinderella of the Australian colonies.

The following table, in the case of the Witwatersrand prepared from the chronicles of the Chamber of Mines, in the case of this country from the data collected by the Customs Department, shows the gold yield of the respective countries for six years. Though set in parallel columns the figures, it will be observed, are not for parallel periods. The starting point, however, is pretty nearly equivalent. The unique "banket" deposits of the Rand were found in 1885; in 1886 the big rush set in, and 1887 was the year of excitement and activity. It is from the latter year that the first records of the Witwatersrand Chamber of Mines date. In Western Australia, towards the close of 1892, Bayley and Ford unearthed the mass of yellow metal at Coolgardie which disclosed the existence of the goldfield and gave the first great impetus to prospecting in the Colony. In 1893 came the rush; in 1894 the Eastern fields were detached from Yilgarn, and declared a separate gold district. So that the periods in the lives of the two countries set in opposition as nearly as possible correspond:—

Rand.			Western Australia.		
		ozs.			ozs.
1887	...	23,149	1894	...	207,131
1888	...	207,660	1895	...	231,572
1889	...	369,557	1896	...	281,263
1890	...	494,817	1897	...	674,987
1891	...	729,238	1898	...	1,050,183
1892	...	1,208,928	1899	...	1,643,876

The table speaks for itself. It affords indubitable demonstration of the excess in the Westralian gold outturn during the first few years of development, the totals being 3,033,349ozs. for the Rand, and 4,088,908ozs. for Western Australia. On the basis of value a comparison of the respective productions would be even more favourable to Western Australia than appears from the above figures.

In other respects Western Australia, in her brief history, outvies the Rand—in the matter of dividends, for instance, of the returns paid to investors by the mines. According to Messrs. Hatch and Chalmers* the total amount distributed among shareholders during the already quoted period of the gold output—viz., 1887-92—was £2,108,350. This distribution falls over $1\frac{1}{4}$ millions sterling short of the payments by Western Australian companies during the past six years, the actual amount in dividends (the figures are those of the Registrar General of the Colony) being £3,576.727. During the year just closed it is worth noting the quantity of gold exported and minted was 1,643,876ozs., while the dividends amounted to £2,022,779, or 25s. per ounce of the precious metal produced.

Area for area, also. of the country opened up, prospected, and settled, Western Australia is far ahead of the Rand; is. in fact, without a compeer. Taking the Witwatersrand goldfield first, the total of the area thrown open to mining does not exceed five hundred square miles. Western Australia, on the other hand, at the time of Bayley's find, possessed, roughly, one hundred thousand squâre miles of proclaimed auriferous country. the gold outturn from which was insignificant—a mere few hundred ounces annually. The rush consequent upon the valuable discovery at Coolgardie is directly responsible for the inclusion in the known gold-bearing area of over two hundred thousand square miles, of which, prior to the find, less was known than of the centre of Africa To-day the total area of the goldfields of Western Australia is 324.111 square miles, or just one-third the area of the Colony. How spacious is the mineral belt may be gathered when it is said to be greater in extent than any province of Australia, with the exception of Queensland.

The Foundation of the Industry.

Gold-mining as an industrial pursuit in Western Australia is of quite recent establishment. The potentialities of a territory encompassing 975,920 square miles were partially known for nearly half a century. As remote as 1854 it was authoritatively declared that the Murchison district probably contained "one of the finest goldfields in the world." For fully 30 years, notwithstanding this prediction, the mineral wealth was suffered to lie *perdu*. Few, if any, attempts were made to make certain of what was accepted as mere probability. The attention of gold-getters at this time was concentrated upon the mineral resources of Eastern Australia, and it was left to one or two explorers to cross the

* "The Gold Mines of the Rand."

Western portion of the continent and acquire indifferent knowledge of the fateful interior. It was not until 1884—Western Australia and its splendid possibilities being still the knowledge of few—that the resources of the out-of-the-way and inaccessible Kimberley district were ascertained. In 1887, again remote from the promised land of the Murchison, the Yilgarn (Southern Cross) field broke out: and four years later the upper Murchison. It was from this time forward that the Colony commenced to fill its destiny.

The work of the prospector, hampered by many embarrassments, has necessarily been slow. An examination of the geological features of the country at once makes clear the reason. The great gold-bearing belt, as we now know it, lies some 400 miles from the littoral, inland and Eastwards of the sand plains, which are ever a barrier to exploration. The successive discoveries on the Kimberley, Yilgarn, and Pilbarra fields allured to Western Australia some of the hardiest and most experienced prospectors the continent contains; and it was as the outcome of their labours that in 1892, towards the close of the year, a small party of prospectors, spurred by what hopes who can say; undeterred by adversity and the frowns of fortune, succeeded in penetrating the desert country east of Southern Cross, a belt previously uninvaded. Their exertions led to the find which took the world by storm, and made the names of Western Australia and Coolgardie famous in every quarter of the globe. A strong tide of men and money flowed to the afar off and hitherto obscure Colony. North, South, and East of Coolgardie the flood of population spread, imposing a severe demand upon the abilities of the State, and necessitating the extension of all public works, the provision of all public conveniences by the Government of the country.

Lacking knowledge of the circumstances, it is hard to picture the many and varied difficulties which have beset the pioneer in the arid wastes of the interior. Even granted personal experience, an adequate pourtrayal of the position is extremely hard. The tedious miles upon miles of inhospitable bush; the lack of water; the paucity of food; the climatic rigors; the topographical obstacles to successful work. Yet in the end, though disastrous often to those who pioneered the way, the country has been opened to settlement, and in the larger centres to civilised life. How potent, too, in all this has been the element of chance. Accidental discovery, often at the close of fruitless, disappointing, and disheartening labour, has metamorphosed the fortunes of individuals and created new scenes of activity for the aggrandisement of others. As before observed, it has been the duty of the Government to follow in the wake of the pioneer, the result being that to-day townsites reserved at varying distances on every field are already either well built substantial settlements or in rapid process of becoming such. The ephemeral hessian, the adaptable iron, are rapidly being supplanted by brick and stone; while careful civic supervision is securing a creditable record for healthfulness. In the remoter districts the

Hannan Street, Kalgoorlie.

townships are still embryonic creations round which the moil and toil of the prospector and the digger go on unceasingly.

Two hundred thousand square miles! And but a few years of prospecting still less of actual mining to demonstrate its full worth. It is truly hard to realise the scantiness of what has been done, how much remains to be achieved. Beyond the potential value for gold of the territory constituting the Eastern Goldfields little has been proved. An immense area is absolutely unknown; an equally large area remains in the hands of the prospector. One may fairly say that barely the fringe of the possibilities of the auriferous country has been touched. In 1893 the bulk of the gold came from surface deposits. The extent and end of those resources was in view. To-day the continuance of ore bodies in length and depth has been proved, and the life of the mines is far greater than was ever imagined by the most sanguine prospector of the early days. Six years ago mining was merely a matter of speculation. To-day it is a question of investment. An industry has been established the opportunites of which are illimitable.

Just as it is true that the full productiveness of the determined gold-bearing belts has not by any means yet been attained, so it may with equal truth be said the arbitrary official demarcation of the goldfields areas by no means circumscribes the limits within which fresh discoveries are possible. There is still ample verge and scope enough as well inside as outside the proclaimed areas for active and profitable prospecting operations. The discovery of the Phillips River District, an extension of the South-West portion of the Dundas field to the coast, is irrefutable evidence of this fact in one direction; while the recent finds in the ranges near Donnybrook, in the very heart of the well-watered and well-timbered South-Western corner of the Colony (concerning which, nearly 40 years ago, Mr. Hargraves, the discoverer of gold in New South Wales, declared that gold in payable quantities would never be discovered) proves it in another.

The most serious obstacle, not alone to the rapid development of the vast auriferous deposits of Western Australia, but to the adequate exploiting of the existing mines, is the very extent of the area proclaimed. This is especially so on the fields most remote from the coast and from railway facilities. A judicious extension of reasonably cheap means of communication will contribute more than aught else to a solution of the disadvantages under which the fields suffer, and to the removal of the obstacles besetting those who are earnestly and intelligently engaged in extending the already far-reaching ramifications of the great gold-mining industry of Western Australia.

The Northern Division.

Dealing with the fields *seriatim*, the first in the Colony to be proclaimed was Kimberley, situated in the remote North-East, on the very borders of the Northern Territory. It was at the outcome of discoveries made by Mr. E. T. Hardman, then Government Geolo-

gist, that, in May, 1886, the development of this distant area originated. The field is an extensive one, comprising 46,886 square miles, all within the tropics; in fact it is the most extensive as it was the first discovered of all. During the preliminary years of its existence the Kimberley District proved to be rich; but, owing to its isolation from the main lines of traffic, little has been done in later years to turn its unbounded merits to account. The export of this field to date has been 25,340ozs.

Next in point of discovery was Pilbarra, proclaimed in 1889. With West Pilbarra recently separated, this field is situated in the region designated the Nor'-West; and, like Kimberley, being remote, its development is fitful and slow. The combined area is 44,360 square miles. The fields are regarded as most promising for minerals. Up to the end of last year their gold production (export) was 158,420ozs.

The two remaining components of the Northern Goldfields, as they are officially styled, are Ashburton, with an area of 6,992 square miles; and Gascoyne, 5,061 square miles. The first-mentioned was proclaimed in 1890, the latter in 1897. To the present the bulk of the gold won on the Ashburton has come from alluvial sources; 4,750ozs. having been exported, mostly obtained from rich patches in shallow ground. In the opinion of experts there are sure to be some very rich deposits of gold in the large plains through which for the most part the Ashburton River flows. The Gascoyne is a comparatively recent discovery. Scarcity of water has greatly hampered the work of those who have been engaged prospecting the field, though the locality is well favoured minerally.

The Central Division.

Taking next the areas constituting the Central Goldfields, the most important in point of present production and of past is the Murchison, proclaimed in 1891, the boundaries of which enclose some 20,513 square miles. The gold bearing belt runs nearly North and South for a distance of over one hundred miles, the different patches being separated either by high sandy table lands or intrusive granite. The field is divided into a number of districts: The Cue district, which again is sub-divided into Cue proper and Cuddingwarra; Nannine, which includes Abbot's, Gabanintha, Nannine, Tuckanarra, Nowthanna, and Star of the East; Day Dawn and Mt. Magnet, the latter district embracing Boogardie, Lennonville, Waringee, and Mount Magnet proper. The activity with which mining operations have been carried on is best demonstrated by the outturn of gold which, to the end of 1899, totalled over half a million ounces. The value of the ore treated has, right through, averaged a little better than an ounce per ton. As indicative of what economical management can achieve under conditions such as prevail on the Murchison—shortage of water and an almost entire absence of timber even for fuel purposes—the following figures relating to the Long Reef Gold Mining Company's property in the Lennonville division of the Mt. Magnet district are

of interest and value. The mine carries a quartz reef, the ore from which returns 15dwts. of gold through the mill (20 stamps), from 5 to 7dwts. remaining in the tailings. Mining costs amount to 13s. 6d. per ton; repairs, with proportion of administration and general expenses representing a further 2s. 3d. per ton. Milling amounts to 11s. 9d. per ton, this sum including transport, repairs to plant, and administrative and general charges. The total cost, therefore, is 27s. 6d. per ton, or about 7dwts., the gold being valued at £3 18s. per oz. The mine yields just sufficient water for requirements, but all the timber used has to be brought several hundred miles by rail. The fuel value of the timber thus obtained is equal to coal at 38s. per ton. Even under these disadvantages mining is possible on industrial lines. The Long Reef is not an isolated instance of successful operations on the Murchison; it is given as typical of many.

Yalgoo, proclaimed in 1895, is to the South of the Murchison, to which field it was at one time attached. Its area is 18,921 square miles, and its production to date 16,670ozs. Last year was the most active experienced from a mining standpoint, the production increasing from 3,765ozs. in 1898 to 10,189ozs. The two leading mines on this field are Field's Find and Woodley's Reward, each owned by English corporations, and each equipped with a 20 stamp mill. At Woodley's Reward the mining and milling of the ore, making provision for all expenditure within the Colony other than that incurred upon development, costs 25s. 9d. per ton.* Timber is not obtainable nearer than 40 miles away; and all the mine supplies are taxed to the tune of £9 per ton freight from the most convenient point of supply.

A field of some prominence, also included in the Central group, is Peak Hill. This field was proclaimed in 1897, has an area of 12,194 square miles, and constitutes an extension northwards of the Murchison belt of country, though it possesses quite distinctive features. Gold was first discovered in the Peak Hill district in 1892; but it was not until some years later that anything other than a mere scratching of the surface took place. Some highly sensational returns have been obtained from the cement deposits which mask the surface of the country and which, in the first instance, were the main source of production. An amalgamation of almost the whole of the Peak Hill leases was some time ago effected, the Peak Hill Goldfields, Ltd., being the name of the company controlling operations. The output of this group in August, 1899, reached 6,314½ozs., the total output of the field being 68,878ozs. A further combination of the leases in the Horseshoe, the only other district of note, has just been completed, the result of which should be a considerable augmentation of the returns from the Peak Hill district.

The East Murchison Goldfield, proclaimed in 1897, with an area of 28,242 square miles, is the remaining member of the Central

* In this, as in all other quoted cases, the average is based on the "long" ton of 2,240lbs., in contradistinction to the practice of the Rand, where the "short" ton (2,000lbs.) invariably obtains.

Fields. As its name implies, the field is a continuation of the Murchison Eastwards. Since the date of the proclamation, the East Murchison has put out over 105,000ozs. of gold. The most active scenes of mining are Lawlers, Lake Way, and Mt. Sir Samuel. There are erected in the districts mentioned some fifteen crushing plants, totalling 127 stamps. Though remote from the coast, and a considerable distance from the termini of the Cue and Menzies railways, a good deal of attention is just now being bestowed upon the development of the expansive stretches within and beyond the confines of this field. The present two most productive mines are the East Murchison United (Lawlers), and the Bellevue Proprietary (Sir Samuel). The Lake Way district also bids fair to become a large producing centre. Several properties have just been equipped with stamp mills, and other leases have been taken up in the same locality, upon which a good deal of energy will shortly be expended.

At the East Murchison United the average cost of mining, based on the work of the past year, is 14s. 5d. per ton, this sum including repairs to plant and a proportion of the administration and miscellaneous expenses. Milling costs, providing for the same charges, as well as for assaying and ore transport, amounted to 10s. 9d. per ton, or a total of 25s. 2d. The monthly tonnage treated was about 1,500 tons, and the average return 24dwts. In addition to the 1,500 tons crushed on the Company's account, some 640 tons per month have been put through the mill for other leaseholders.

The Eastern Division.

It is on the Eastern Goldfields that the most remarkable developments have occurred, and from them that the great bulk of the gold exported from the Colony during the past five years has come. And in any reference to this group, East Coolgardie falls into pride of place: in dimensions almost the least significant of the seventeen goldfields in Western Australia; in production pre-eminent. During 1899 the yield of the precious metal from the Boulder mines, practically the only contributories, was 917,434 ozs., or more than half the aggregate of the yield from the Colony. This production is in excess of that from Victoria; not far short of that from Queensland; and it is ahead of the return from the Rand at the same stage of development. Compared with the production in 1898 the output for the past year shows an advance at the rate of one hundred per cent.

The history of the East Coolgardie Goldfield has been one long succession of surprises and of phenomenal developments; with the result that to-day no camp displays so plenteously the actualities of progressive mining. Operations are almost entirely confined to the tract of country contiguous to the town of Kalgoorlie and extending Southwards for a distance of five miles. Along the whole length of this line the eye is met in every direction with a succession of substantial equipments. As the "Golden Mile" (the name bestowed upon the Boulder bunch of mines) is reached, the surface of the ground is entirely covered by the immense structures

Bayley Street, Coolgardie.

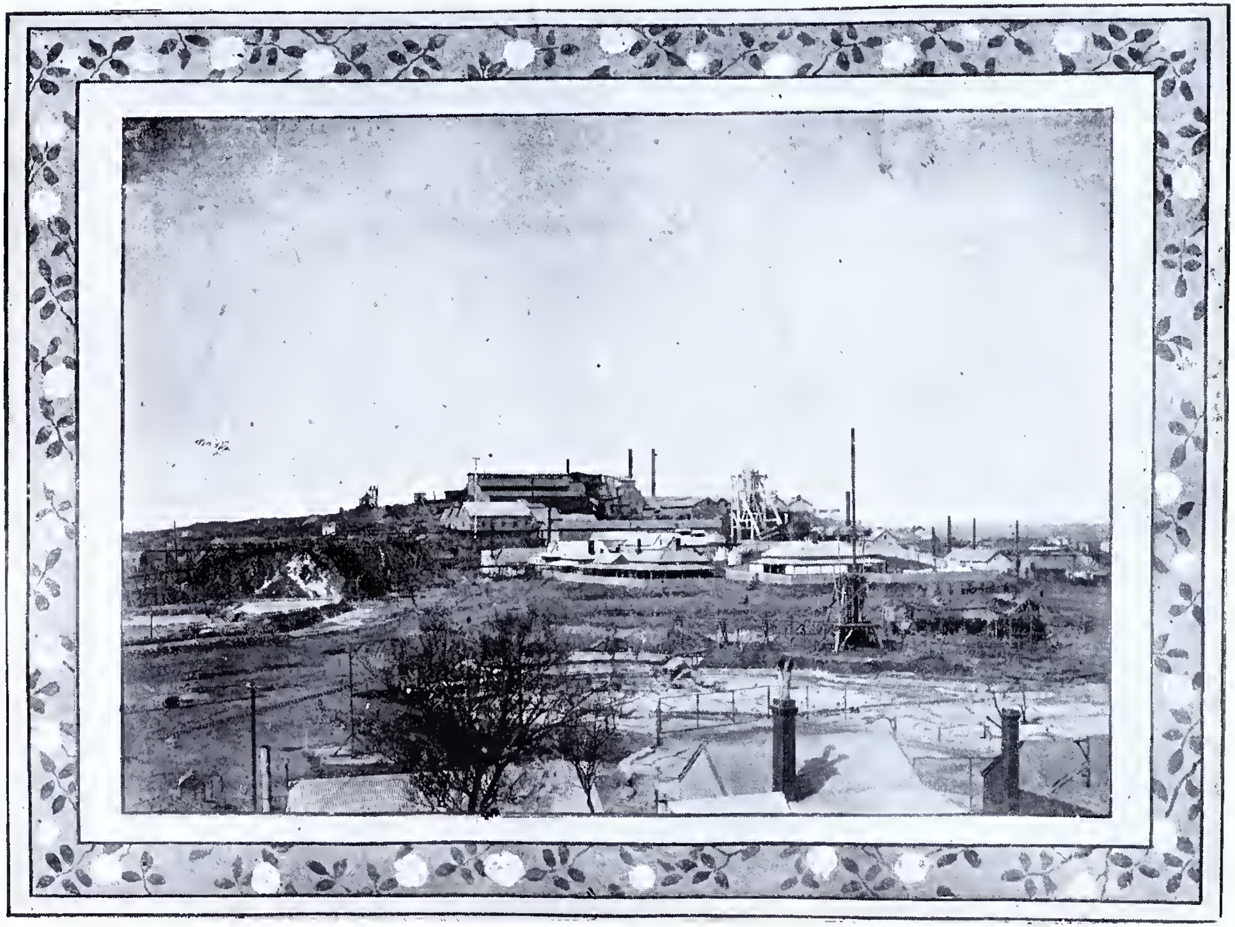
enclosing the reduction plants and other works incidental to the extraction of gold from its matrix. At the moment, the quantity of mill stuff treated per month is about 40,000 tons, the average of the returns being 1oz. 17dwt. The exploration of the deeper ground is proceeding as quickly as the free provision of funds and the employment of up-to-date and advanced methods will permit. In the Great Boulder mine where, in this regard, the most active policy is in vogue, the value of one, at any rate, of the ore bodies at a depth of 1,100 feet has already been ascertained; and it speaks volumes for the future of the field, and for the country, that not only the width but the high values which from the inception have been so characteristic of the composite lodes of East Coolgardie are fully maintained. The experience of the Great Boulder, the pioneer mine of the field, is the experience of other properties. As depth is attained, rich zones of ore are being encountered, the existence of which was previously unknown; while the extensions, laterally and longitudinally, of proved ore bodies are being picked up in adjacent leases.

Over 900,000 tons of ore have been raised from the mines along the Hannans belt, the yield from which was 1,720,000oz., or an average of just short of 2oz. per ton. The bulk of this stuff has, of course, been drawn from the oxidised zone, which superimposes the unaltered country for a depth varying from less than 100 to several hundred feet. Below this are the telluro-sulphide and sulphide ores, the profitable manipulation of which is just now receiving close attention. The accepted practice of the field has been to apply wet milling to the reduction of the oxidised ores, the residues being invariably leached with cyanide solutions. The notable exceptions to this rule are the Hannans Brown Hill and the Associated (Australia) mines, where, instead of wet milling, the reduction of the ores by dry processes has been adopted with signal success. Some interesting figures are available concerning the work of the former mine during the year just closed. In this period the quantity of mill stuff treated was 42,025 tons, which yielded 87,762oz. of gold, valued at £347,539. Out of this sum £123,750 was distributed in dividends. The expenditure on capital account —on mine development, on construction and equipment—was £43,219; and on revenue account, on ore extraction, reduction, etc., £89,659; mint and bank charges representing £3,992 of the sum total. The average cost per ton of milling was 12s. 2d., inclusive of ore transport, maintenance, and administration; cyaniding, 11s. 10d. per ton; and mining 11s. 11d., or a total of 35s. 11d. per ton. The percentage of fine gold recovered was 94·35 of the ore contents.

So much of the current work in the mines is now within the sulphide zone that naturally the managements have been seeking to devise an efficient and economical process for the treatment of these ores. From most of the mines parcels of sulphides have from time to time been shipped to smelters. The returns are invariably high, ranging from a few to thirty or forty ounces per ton; this

procedure prohibiting the forwarding of any but the richest ores. Here is a case to show the expenses: The parcel contained 203 tons 9 cwt. gross weight, or less tare and moisture 197 tons 14 cwt., and contained 1,966 ozs. of gold. The gold paid for was 1,927·65 ozs. at £4 per oz., £7,710 12s. 2d. Smelting charges (£2 per ton) amounted to £395 9s. 6d., and the freight £99; reducing the net proceeds handed to the company to £7,228 11s. 3d. It will be gathered from these figures how expensive, and therefore how prohibitive the shipment to smelters is under existing conditions. Local treatment has been attempted at several of the mines; notably at the Lake View Consols, the Boulder Main Reef, and the Associated. Several other properties are being equipped with costly and elaborate plants. Generally speaking, the lines of treatment adopted have been as follow:—Drying in revolving furnaces of ordinary type; trituration with rolls and ball mills; roasting or desulphurising in horizontal furnaces of the "Ropp" type, or in vertical furnaces; and a subsequent leaching of the sweetened product by solutions of cyanide of potassium. In some of the later plants provision is made for the extraction of whatever coarse gold there may be in the ore by passing the residues at some stage of the process over amalgamated plates or into pans. It cannot be said that, to the present, the efforts to handle the sulphide ores on the field have been attended with unqualified success. The experience has rather been that the costs are high and the extraction low. Experiments are in progress at the Lake View Consols which involve a complete departure from the methods already described. The author of the new process is Dr. Diehl, of the London and Hamburg Gold Recovery Company, the firm responsible for the system of reduction applied at the Brown Hill mine. Briefly, the points of differentiation are that the ore, instead of being dry crushed, is passed through stamp mills in the ordinary way, the pulp being concentrated, and the tailings submitted to direct cyanidation. Both the drying, which is a condition precedent to reduction in ball mills, and the roasting, which was deemed requisite to eliminate the sulphur before applying the cyanide solutions, are thus dispensed with; the direct treatment of the raw product, after wet crushing, being found not only more economical but to afford a much higher percentage of extraction. If, after further tests, the system devised by Dr. Diehl be found as advantageous as the preliminary trials have proved, then the manipulation of the mineralised ores of the East Coolgardie Goldfield will be a much simpler and a much less costly matter than was believed; and the difficulties which for a time loomed in the way of the maintenance of the present production will have been removed. The mines right along the line are opening up remarkably well, and, given a satisfactory solution of the "sulphide problem," the yield of gold from the East Coolgardie field must, in the future, show even greater advances than in the past.

Next to East Coolgardie in point of production is Coolgardie, the parent of the Eastern Goldfields. It was the magnificent finds made at and in the vicinity of Coolgardie that first attracted world-



The Lake View Consols, Kalgoorlie.

wide attention to the opportunities afforded by Western Australia for those whose interest is centred in gold mining, and that enabled an obscure and disregarded country to, for the time, dominate the attention of the mining world. As a gold producer Coolgardie still ranks second in importance, the outturn in 1899 (141,170ozs.) being the largest yet recorded. In view of the almost entire cessation of outside interest in the resources of the field, due possibly to the overwhelming claims of Kalgoorlie to immediate attention, the improvement is noteworthy. The present producing mines have yet to touch the high water mark of their yields; while among the "silent" mines are many which sooner or later will enter the ranks of the producers. Outside Coolgardie proper, whence the greater portion of the gold at present comes, there are a number of important centres:—Burbanks, Bonnievale, Londonderry, Red Hill, Kunanalling, Kintore, 42-Mile, and Siberia, in all of which a renewed activity is noticeable; an activity created by and resulting in new discoveries. Enterprise on the part of capital and good management have still a profitable sphere of operation round Coolgardie, where there are as many leases undergoing steady development by individual miners as anywhere else in the Colony. Generally speaking the ores of the field are low grade; that is in comparison possibly with those won elsewhere in the Colony; but no difficulty is experienced in working them at a profit. The leading Coolgardie mine at the present moment is Bayley's United. Bayley's is an amalgamation of four mines, and four distinct reefs are being exploited, the intermediate distances necessitating the transport of the ore by cable hoist from a central station 1,000ft. removed from the mill. During the past year the working costs have averaged 30s. 4¾d. per ton, apportioned as follows:—Mining, 15s. 8½d.; milling, 8s. 0¾d.; and cyaniding, 6s. 7½d. per ton. The manager anticipates that, allowing for the treatment of the slimes by the filter press process, the working costs during the current year will not exceed 31s. 4d. per ton. At the Vale of Coolgardie (the leading producer in the Bonnievale district) the mine expenses are officially stated to be as follow:—Mining, 15s. 9d. per ton; milling, 8s. 9d. per ton; and cyaniding, 5s., or a total of 29s. 6d. per ton. Both mines are quartz propositions. The average yield from Bayley's is 30dwt., from the Vale of Coolgardie 12½dwts. per ton.

The only field which retrogressed in its gold production last year in contrast with the previous year was North-East Coolgardie (21,542 square miles), the chief district and centre of which is Kanowna. The bulk of the gold turned out from this field has latterly come from the "cement" or the "alluvial," as it is indifferently termed. At comparatively shallow depths the several leads being worked returned rich values, the yields from this source sending the production up with a jump from 32,906 ozs. in 1897, to 125,240 ozs. in 1898, and 81,171 ozs. last year. The falling off in the outturn in 1899 is attributable partly to the exhaustion of the richer portion of the deposits, but mainly to the lack, on the part of the working miner, of the capital wherewith to prosecute his

labours at depth. The existence of beds of conglomerate, alternated with bands of "pug" (a soapy stuff in which the gold occurs in an extremely fine and filmy state) has been demonstrated to a depth of 200 feet. As most of the holdings are claims, and not leases, the field therefore labours under a dual disadvantage. In the first place, as before mentioned, the working miner has not the means to purchase plant to enable him to go below the water level (80 feet), and in the second place the smallness of the holdings is a bar to his getting funds from extraneous sources. These disadvantages will be overcome when it is found possible to amalgamate a number of the claims on a reasonable basis, this being absolutely essential before sinking can be resumed. Latterly there has been a marked revival in quartz mining. The White Feather Reward, the chief property in the district, continues to furnish good returns; and at the White Feather Main Reef, and the North White Feather Consolidated, adjoining mines, work has recently been re-entered upon with promise of payable results. The disclosure of several large formations underlying the cement, it is anticipated, will constitute a further source of production in the not very distant future. In the Bulong district the outlook is equally promising, both for alluvial and quartz mining.

The Broad Arrow field, 590 square miles in area, embraces the districts of Black Flag (some years ago a very busy spot), Bardoc, Paddington, and Smithfield. It ranks eighth on the list of producers; the output of the precious metal in 1899 being double that of 1898. Two of the mines on this field stand in the forefront with the best in the Colony, the Hill End at Broad Arrow, and the Paddington Consols at Paddington. The extension of the railway Northwards from Kalgoorlie has done much to improve the conditions under which mining is carried on in this district. Operations were at one time greatly impeded by the shortage of water; but as the lower levels are driven, this drawback has in a great measure been obliterated. At the present time the costs of mining compare most favourably with those of other fields. At the Hill End mine, for instance, owned by the New Austral Company (largely French capital), the expenses are: Mining, 12s. 2d.; milling, 10s. 9d.; cyaniding, 7s.; while special charges, such as rents, insurances, etc., represent a further 1s. 5d. per ton; the total charges amounting to 31s. 4d. At Bardoc and Black Flag many leases continue to be worked on an industrial basis.

Public attention is just now largely directed to what it is customary to refer to as the "North Country." By this is meant that portion of the Eastern Goldfields included within the areas of North Coolgardie and Mount Margaret. The whole of the belt, or the greater portion of it, is still in the hands of the prospector and of the miner, who, working as owner, is steadily developing and reaping the returns from the small parcels of ore raised and treated at some convenient crushing mill. The North Coolgardie field, 30,609 square miles, comprehends the country which radiates from Menzies and enfolds the important centres of Comet Vale, Goon-

The Great Boulder, Kalgoorlie.

garrie, and the districts of Ularring (which includes Mount Callion, Mount Higgins, Mount Ida, and Mulline), Niagara (which also embraces Tampa), and Yerilla (Linden, Eucalyptus, and Edjudina). Over this extent of mining country some 400 stamps have already been erected. At the Lady Shenton G.M., Menzies, the average cost of mining was 16s., and milling 15s., inclusive of all charges, and taken over a period of four months. A number of the more important interests are in the hands of English companies, the rich specimens obtained in the early days from the mines in this belt proving a great stimulus to the exploitation of its mineral wealth. To the end of 1899, the returns of gold from the leases on the North Coolgardie field totalled 278,343ozs. The various camps have suffered more than the usual number of vicissitudes. There is practically no water in the country, and the difficulty in obtaining supplies, much less the bare necessaries of life, prior to the extension of the railway system, compelled the abandonment of many areas which, under the altered conditions of the present, it is possible to handle with profit, areas also, some of which have recently shown themselves to be of great promise. In each of the centres mentioned is generally to be found a group of leases, the intervening 10, 12, 20, or more miles having only been subjected to the most cursory examination. Yerilla is a case in point. Some of the richest specimens obtained in Western Australia came from this district. As a surface field, it was highly appraised. Large quantities of gold were also got from the alluvial. Subsequent developments, however, were far from fulfilling the anticipations formed at the first. Many leases were abandoned, and the district became unfashionable. Just North of Yerilla a new belt of country has recently been discovered, called "The Granites." For four miles gold-bearing stone outcrops; but whether this is a continuous reef, or a succession of chutes, has yet to be determined. This is only one of many developments constantly reported from the North country, along the length and breadth of which prospecting operations are being vigorously pursued.

Mount Margaret (42,154 square miles) comprehends within its boundaries the most central portion of the Colony yet proclaimed a goldfield. Two spacious districts are embraced—Mt. Margaret and Mount Malcolm. Taking again the subdivisions which indicate the mining settlements we have classed under the first named, British Flag, Erlistoun, Laverton, Mount Weld, Eagle's Nest, Quartz Hill, Redcastle, and Mount Morgans; while in the Mount Malcolm district are Diorite King, Leonora, Malcolm, Murrin Murrin, Mertondale, Randwick, and Webster's Find. On the whole field there are 264 stamps erected, besides other reduction and cyanide plants. Mount Margaret has come to be recognised as a most important mining field; in fact, outside the Hannan's (East Coolgardie) belt, the most important yet found in the country. Most attention has been given to and the best results have been obtained from the mines in the Malcolm district, though immense strides have latterly been made by the Margaret section proper, particularly at Mount Morgans. Here are some large lode formations, which, in the mines

exploiting them, are yielding remarkable returns. Trouble has been experienced in securing a sufficiency of water for milling purposes, but this is practically settled, and considerable impetus will be given in the current year to the further opening up of the ore bodies, the outcrops of which, traceable for miles, are prominent features of the field. At other points, Redcastle notably, many men are to be found dry-blowing, new gullies being found almost every month. Among the new centres in the Margaret district, the Euro (Laverton) is coming into prominence. Its position is some 20 miles from Mount Morgans. Curiously enough the original holders of the Euro mine—and their experienee exemplifies how difficult it is to command sueeess, however well deserved—mined to within $8\frac{1}{2}$ inches of the lode now being worked, the discovery of which has completely transformed the prospects of the property. East of Mount Weld, a centre 33 miles East of Mount Margaret, a find was recently made which constitutes the nearest line of reef to the South Australian border yet exploited. Except spinifex, nothing has so far been proved to exist East of this new locality. The find is known as Bett's Find. The best developed mine is the Black Swan, where the indications are exceptionally good. In his 1869 expedition Sir John Forrest penetrated to within a very short distance of this new mining camp; but was compelled to return owing to the scarcity of water. North of Laverton some 64 miles, a range of gold-bearing country, broken up with bands of desert spinifex and out-cropping granite traceable for over 100 miles, is just now coming into prominence. Some years ago this line was taken up by a strong corporation, and abandoned. English capital has again been introduced, and within the next 12 months we may expect to hear of excellent results attending a poliey of energetie development. Though first prospected in the early days, comparatively little is yet known of the Erlistoun country. Some hundreds of miles North-East again is another auriferous belt, the prospectors of which brought in some exceedingly rieh speeimens with the statement that there is plenty more of the same sort of stone waiting to be won. On the strength of their representations a strongly equipped expedition was formed a few months ago, backed by Coolgardie capital, to thoroughly explore and test the country in the region of the find.

The various districts constituting the Mount Malcolm division have contributed the bulk of the total output from the field. A marked characteristic of this, as of some portions of the Margaret division, is its plenitude of fresh water, which makes living under conditions even superior to those obtaining in the larger centres. Indeed the town of Malcolm is distinguished in the droughty interior as the town of wells and windmills; and as being the only town on the goldfields where water is reticulated for domestie purposes from elevated tanks. In the neighbourhood of Malcolm is the first quartz claim pegged out in the North country. It is familiarised under the name of the North Star. Speakman and party made the location after the original Darlôt rush. Not good

The Brown Hill Mine, Kalgoorlie.

enough as a dollying show—this being the test of value in those days—the ground was forfeited, and re-pegged by prospectors who ultimately sold out to English investors. The property has been systematically developed, the output to date being 5,396ozs. from 5,217 tons. Recent discoveries have materially enhanced the value of the property, which is becoming one of the most important and most promising on the field. The average value of the mines of Malcolm, and also of Leonora, is an ounce to the ton. North of Malcolm is Mertondale, a comparatively new district. Its discovery was the "accident of an accident," the result of a fortuitous mishap. Merton, the prospector, tracking a strayed horse, happened upon a gold mine, from which in a few months he raised 241 tons of stone, which yielded 1,428ozs. of gold. North-west of Merton's another find has recently been made by Dunn, the original prospector of the Wealth of Nations, and this also is reputed to be wonderfully good. East of Malcolm is the Australia United group, a congeries of leases producing a considerable quantity of gold. This is one of the few camps in the North where water is not plentiful. Bummer's Creek, Webster's Find, Murrin Murrin (where is situated the Mt. Malcolm Proprietary, one of the best equipped mines on the field), and Leonora (which has all the characteristics of Hannan's, save that it carries no tellurides and contains an amplitude of water) are all centres of marked activity and of expanding production. Two years ago there were not more than 20 operative stamps in the district; to-day there are 183, and others in course of erection. The mine in the Malcolm district which, more than any other, has brought the "North Country" into prominence is the Sons of Gwalia, at Leonora. This property alone has turned out over 38,495ozs. from 34,055 tons of ore, the reduction plant consisting of a 10-stamp mill. Sixty-eight miles removed from the nearest railway, the expenses of production must necessarily be high. Careful management, however, has brought them into line with the best that is being done in the country. Taking the averages of the past year, mining cost 11s. 10d.; milling 7s. 1d.; the total expenditure under the two headings being 18s. 11d. per ton of ore treated.

Yilgarn, containing 15,593 square miles, proclaimed in 1888, is distinguished for the low value of the ore treated, and for the economy which has marked the management of its principal mines. The records show the ore raised and treated to have averaged only 10dwts. per ton; and out of this, in spite of expensive transport during a considerable period of the field's history, and shortage of water always, it has been possible to pay close upon £50,000 in dividends. In the course of underground exploratory work the existence of a formation, worth 25dwts. to the ton, was last year discovered in the Fraser's South Extended mine. This formation has since been traced for some distance both North and South; and besides immediately improving the mining prospects of the Southern Cross district, it has drawn attention to the presence of gold-bearing bodies other than the quartz veins, which have been the main source of production in past years.

Dundas, with 17,848 square miles, proclaimed in 1893, is the remaining field in the Eastern group. It is really an extension Southwards of the Coolgardie field. Despite its isolation from the rest of the mining centres, the field has been one of the most consistently progressive. It was in 1896, in which year two batteries only were operative, that the production of the field really commenced. In succeeding years the output of gold has grown from 4,000 to 19,000, from 19,000 to 32,000, and from 32,000 to 42,000 ounces in 1899. There are now 185 stamps erected, the yields averaging an ounce to the ton. The most important mine is the Norseman Gold Mine, the turnout from which represents one-fifth of the gold credited to the Dundas field. On this property, handicapped by 100 miles or more of transport charges from the nearest railway station, the cost of mining compares favourably with other and better favoured centres. Including all charges, with the exception of development, the total expenses are 22s. per ton of ore treated; mining representing 14s. 6d., milling 6s. 6d., and special charges (rents, insurances, etc.) 1s. per ton.

Within the goldfields area, yet excluded from its operations, is the extensive estate of the Hampton Plains Syndicate. The area of the locations, all freehold, aggregates 217,000 acres, the blocks extending from the immediate neighbourhood of Coolgardie to the heart of the North-East Coolgardie Goldfield. Most important, in view of surrounding circumstances, are those blocks which enclose the stretch of country from Coolgardie to the shores of Lake Lefroy, and carry the southern extension of the Hannans line. The Company's regulations controlling mining are practically on all fours with those issued by the Government; and it is the policy of the present administration to offer every incentive to prospectors and miners to test the resources of the Estate. Several rich alluvial patches have been worked during the past year, and it is not too much to expect that systematic search must result in the finding of more than payable propositions on the clearly marked mineral belts traversing the blocks.

Gold has also been found in several localities not comprehended by the goldfields areas already described, notably at Donnybrook, a few miles inland from the port of Bunbury, and South of the Collie coalfields; and at the Phillips River, some distance East of Albany. The main merit of these, as of other isolated finds, is the corroborative demonstration they afford of the immense extent of the auriferous deposits of the Colony, and the splendid opportunities they present for the experienced prospector and the industrious miner to turn the mineral wealth of Western Australia to account.

The Donnybrook field is in its infancy, gold having been discovered thereabout, but a considerable amount of development work has been done. Its extent is about five miles long by about one and a-half miles in width. Donnybrook is most favourably situated as regards timber, water, railway, and shipping facilities. It is distant 130 miles by rail from Perth, and is connected by rail with the sea-

The Australia Associated Mine, Kalgoorlie.

Showing Open Cut.

port of Bunbury, which lies 24 miles away. The gold occurs, when free, in a crystalline form in the shape of fern leaves, apparently of secondary origin, and also in connection with sulphides.

The number of leases taken up is 200, the names of the most important being Queen of the South, Hunter's Venture, Mount Cara, Donnybrook Gold Mine (Cammilleri's), Bullington, Hislop's, Okeley's, Roger's Claims, Donnybrook Main Lode, and Donnybrook Regent.

The following are some of the latest crushings to hand:—Hunter's Venture, 110 tons for an average of 19dwts. per ton; Cammilleri's (Donnybrook G.M.), 51 tons for 115ozs.; and Queen of the South, 116 tons for 339ozs. From the last-mentioned mine 60 tons of ore were treated at the Western Australian Smelting Works, Fremantle, for a yield of 175ozs. 4dwts., (an average of 2ozs. 18dwts. per ton.

There are 18 declared goldfields in the Colony, embracing a total of 324,611 square miles, distributed as follows:—

	Square Miles.		Square Miles.
Kimberley	46,886	Broad Arrow	590
Pilbarra	34,880	North Coolgardie	30,609
West Pilbarra	9,480	North-East Coolgardie ...	21,542
Ashburton	6,992	East Coolgardie	632
Gascoyne	5,061	Coolgardie	11,974
Peak Hill	12,194	Yilgarn	15,593
Murchison	20,513	Dundas	17,848
East Murchison	28,242	Donnybrook (approximate)	500
Yalgoo	18,921	Phillips River Mining District	1,300
Mount Margaret ...	42,154		

The following table shows concisely and clearly the growth of the Gold-mining Industry. The yearly output is as under:—

Year.	Quantity.			Value.		
	ozs.	dwts.	grs.	£	s.	d.
1886 ...	302	0	0	1,147	12	0
1887 ...	4,873	0	0	18,517	8	0
1888 ...	3,493	0	0	13,273	8	0
1889 ...	15,492	10	0	58,871	10	0
1890 ...	22,806	6	6	86,663	19	9
1891 ...	30,311	1	9	115,182	1	2
1892 ...	59,548	6	4	226,283	11	5
1893 ...	110,890	18	5	421,385	9	2
1894 ...	207,131	6	6	787,091	16	10
1895 ...	231,512	13	21	879,748	4	9
1896 ...	281,265	0	0	1,068,707	0	0
1897 ...	674,993	17	2	2,564,976	12	9
1898 ...	1,050,183	11	23	3,990,697	13	6
1899 ...	1,643,876	14	7	6,213,914	7	7
Total ...	4,336,680	5	11	16,446,460	11	11

Return of Gold in Ounces, as reported to the Mines Department, from each Goldfield up to 31st December, 1899.

Goldfield.	Previous to 1898.	1898.	1899.	Total to Date.
Kimberley	12,963	440	917	14,320
Pilbarra	35,296	14,414	19,318	69,028
West Pilbarra	1,198	327	1,935	3,460
Ashburton	303	501	1,659	2,463
Gascoyne	14	14	333	361
Peak Hill	21,954	14,970	31,954	68,878
East Murchison	23,571	37,080	45,041	105,692
Murchison	202,748	79,256	81,085	363,089
Yalgoo	10,683	3,299	12,136	26,118
Mount Margaret	27,584	49,718	80,124	157,426
North Coolgardie	88,325	72,879	117,139	278,343
Broad Arrow	23,594	27,726	48,308	99,628
North-East Coolgardie ...	49,429	170,441	112,843	332,713
East Coolgardie	440,593	422,392	855,406	1,718,391
Coolgardie	138,973	99,673	126,143	364,789
Yilgarn	111,267	11,769	16,373	139,409
Dundas	23,263	36,798	44,358	104,419
Donnybrook	...	15	511	526
Goldfields, generally	...	...	1,279	1,279
Total	1,211,758	1,041,712	1,596,862	3,850,332

The number of stamps employed during the fourth quarter of 1899 amounts to 3,299, ball mills 28, other mills 52, cyaniding vats 361, filter presses 23. The average number of men employed above ground was 8,184, and below ground 9,096, to which must be added 3,235 diggers, totalling 20,515. The average per ton of ore treated for the quarter pans out at 1oz. 7dwts. 12grs. for 317,708 tons reduced.

Dividends up to the end of 1898 amounted to £1,553,948, during 1899 to £2,022,779, totalling in all £3,576,727. These figures bring us up to 17th January, 1900.

COLLIE COAL.

East of Bunbury and on the eastern slopes of the Darling Range are the Collie coalfields. The journey to them passes through the Darling Range at one of its most picturesque points. The sides of the hills are timbered with magnificent jarrah forests. It is indeed a revelation to undertake the ride. Thousands of acres of rich land heavily timbered with stately jarrah trees and other indigenous timber are traversed. The value of the jarrah opened up by the branch line from Brunswick to Collie can only be represented by a large sum. Timber mills are in the thick of the forest, converting the trees into marketable commodities. At stations on the journey truck loads of jarrah, cut into paving block dimensions, are seen awaiting transit to Bunbury or Perth. There they are loaded into vessels and despatched for London, where the use of jarrah for street-paving purposes is steadily on the increase.

Past History.

The history of the Collie coalfields is similar to the history of many other industries in Australia, the joy of the first finder being discounted by reverses and discredit, and many years elapsing before success rewards enterprise. In the year 1889 Mr. Arthur Perrin, a squatter in the Brunswick district, entered into an agreement with a Mr. D. A. Hay to show him the locality of a find he had made of a formation supposed to be carboniferous. After visiting the locality, and proving the deposit to be true coal, Mr. Hay, associated with other prominent people of Bunbury, formed a company for the purpose of developing the same. Although many efforts were made to exploit one of the seams, those efforts had to be abandoned for want of capital and for lack of faith on the part of the public. Faith in the value of the deposits at the Collie seemed utterly lost for a few years, until shortly after the inauguration of Responsible Government the subject again received attention. The Government decided to invite Dr. Robinson, F.G.S., a well-known coal expert in New South Wales, to inspect and report upon the deposits. This gentleman visited the colony in the year 1891, made a very exhaustive examination of our coalfields, and reported favourably, saying good coal undoubtedly existed. Acting upon this opinion, the Government, with that energy which has ever marked their administration, and acting under the advice of the then Commissioner of Railways—the Hon. H. W. Venn—commenced a methodical and exhaustive system of boring, under the direction of Mr. Pendleton, proving beyond doubt the truth of Dr. Robinson's report. Not satisfied with this, the Commissioner, with a faith in the coal deposits which few others at that time shared, and on behalf of a Government anxious at all times to force the colony ahead, started to raise coal. Com-

mencing from the outcrop, everything was done economically, so far as the conditions of the country would allow; but the distance—27 miles or thereabouts—from the nearest point of railway communication involved heavy expense in transit. The Commissioner, on behalf of the Government, determined to raise 1,000 tons of coal, and called for tenders for carting the same from the pit's mouth to a point on the South-Western Railway line, finally accepting a tender for £3 per ton. The coal, being a good, sound, and serviceable fuel, was then tried extensively on the South-Western Railway system, and was distributed gratis to foundries, manufactories, and private consumers, demonstrating beyond doubt the usefulness of the Collie coal as a fuel. It was exhaustively tested. The railway locomotives gave it tests under all sorts of trying conditions. It was also used in other classes of boilers. The verdict, resulting from many trials, was favourable. Influenced by such results, the Government introduced a Collie Coalfields Railway Bill into Parliament, and carried it through. At this time there was not a colliery at work. Private enterprise had practically done nothing. The Government had opened the field, had proved it, and were now to give it adequate means of transport. Of such are the problems that colonial governments are often called upon to undertake with caution, with courage, and with vigour.

A Bold and Successful Policy.

When the railway was finished, another colliery company on the Collie started operations. Later, when the company shut down—after having earned a bad reputation for the article—it looked very much as if the railway, and other State undertakings in connection with the Collie coal, were doomed to be grave financial failures. At this juncture, however, the Government leased its mine on the Collie on most advantageous terms. The lessee and his manager were practical men, with a keen knowledge of their business. Before long Collie coal, of a superior description, was being sent all over the colony. In a few months the fame of the local article grew. Now it has established itself as a valuable fuel, and the two collieries at work have a difficulty in meeting the demand for it. Thus the bold policy of the Government in opening up the coalfields, and in building a costly railway to them, has been justified many times over. The Collie coalfields are one of the most magnificent resources of Western Australia.

Practical Tests.

Every coal has an individuality in the furnace. The stoker knows that to get its best work each type of coal requires a special treatment. A caking coal like the Newcastle wants plenty of breaking up and slicing, and demands a draft on the top of the fire. A non-caking coal like the Collie, on the other hand, demands no slicing, and wants a draft from the bottom. Many of the first tests of this coal were made in ignorance of how best to treat it, and in consequence the best results were not obtained. The first

practical test of any telling value was made by Mr. MacDougall, chief-engineer of the steamer "Tangier," which plies in the cattle trade between Wyndham and Fremantle—a distance of 2,000 miles. At the time the figures subjoined were obtained the "Tangier" had practically steamed 5,000 miles with Collie coal. The test, therefore, was of a convincing nature. In the course of a press interview, Mr. MacDougall spoke in this manner: "Here are the daily runs from Fremantle to Wyndham and back, as observed by the navigating officers and handed by them to me. Going up we used Collie coal exclusively, and our supply ran out when we had come back about four days on the return journey. We then used Newcastle coal exclusively to Fremantle. Now just see how it pans out."

TO WYNDHAM WITH COLLIE COAL.

1899.	
April 6 (partially)	175 knots.
" 7 "	210 "
" 8	193 "
" 9	207 "
" 10	195 "
" 11	174 "
" 12	187 "
" 13	201 "

FROM WYNDHAM WITH COLLIE COAL.

April 15	228 knots.
" 16	199 "
" 17	199 "
" 18	193 "

WITH NEWCASTLE COAL.

April 19	181 knots.
" 20	183 "
" 21	168 "
" 22	186 "
" 23	195 "

"There were only light breezes throughout, and this fact told to the disadvantage of the Collie coal for this reason. The local article requires a good draft to yield its best work. The 'Tangier' has only a natural draft and with the light winds abaft we had very little help for our fires.

"The Collie coal gives out little or no smoke, and this is a most important consideration. From Fremantle to Wyndham, using Newcastle coal, the firemen have to clean the tubes twice; with Collie coal only once. Naturally the firemen prefer to work the local article."

Its Lasting Qualities.

Mr. MacDougall was very enthusiastic as to the lasting qualities of the Collie coal. Speaking on this subject he delivered himself as follows:—"In this respect it is far superior to any coal I have ever seen used. With quick burning coals the difficulty is to get a proper combustion in the proper place. Using Newcastle coal, for

instance, a lot of the heat-giving elements pass through the funnel in the form of dense smoke. I have seen the flames from Newcastle coal come through the top of the funnel. Obviously, much of the benefit of the coal is lost under such circumstances. The heat is wanted in the combustion chamber and in the tubes, but not in the funnel. That is the trouble with all quick burning coals, they make a big, fierce blaze, and spend a lot of their heat where it is not wanted. On the contrary, the Collie coal behaves quite differently. In the first place it is slower in getting away, which is rather a disadvantage; but once it is properly going it gives out a most fierce heat. It has a very small flame, not more than a foot high, and pure white in appearance. The advantage of this sort of heat is that it is distributed in the combustion chamber and through the tubes just where it is wanted."

As a Naval Fuel.

Mr. MacDougall continues in this strain:

"I think the coal will be of the highest value for naval purposes. I do not know of a coal which gives off such an invisible smoke. The Newcastle produces a very heavy black cloud of smoke, and that is a disadvantage for men-of-war when engaged on active service. Considering the non-smoking nature of the coal, its grand steaming capabilities, and its valuable position—situated on the extreme Western coast of Australia—I think the attention of the naval authorities is bound to be attracted to it.

"I feel sure the coal will be in keen demand. It will be used for all intercolonial shipping, and the big mail steamers will use it between Fremantle and Colombo. I have given the question very close study, and have tested the coal until I know its capabilities thoroughly. I am convinced it has a great future."

The Limitations of the Coal.

The coal, while admirably adapted for all steaming purposes, has its limitations. It is of no use for gas-making purposes. It is also doubtful as to whether it will answer for smelting works. Its small flame is considered a disadvantage for such purposes. It has also a comparatively light specific gravity, which is a disadvantage, in that it takes up more valuable space on a steamer than other coals. But so far, the coal that has been tested is near to the surface. In its deeper levels the hope is entertained that the coal will be of a superior character.

The Trial on the "Sommerfeld."

The German cargo steamer "Sommerfeld," of the German-Australian line, steamed from Fremantle to Adelaide with Collie coal. The report of the Captain was to this effect: "I hereby give you a report on the Collie coal. We used this article exclusively during the voyage from Fremantle to Port Adelaide. We found the coal very slow in getting away at the beginning, but, once properly going, it gave a good heat and kept steam perfectly well,

giving only a small flame and almost no smoke. The daily consumption was 30·5 tons against 27·5 tons of New South Wales coal received at Adelaide on the previous trip. Ash 14·5 per cent. as against 30 per cent. of our supply from Adelaide on the previous voyage. As the 'Sommerfeld' is rather hard to keep under full steam, the engineer had to keep up heavy fires on account of this and the very rough seas encountered. We did not get the best results from the coal. In the engineer's opinion the Collie coal requires a good draft, and the fires should not be disturbed."

In a private letter received by the agents of the steamer—Messrs. Strelitz Bros.—from the chief engineer of the "Sommerfeld," that officer states that with a proper draft the coal is admirably adapted for steaming purposes.

The "Royal Arthur" Tests.

The flagship of the Australian Squadron, the "Royal Arthur," with Admiral Pearson on board, visited the Western Australian ports in June, 1899. The Western Australian Government made the Admiral a present of 100 tons of Collie coal in order that its value for naval purposes might be ascertained. Speaking to a representative of the *Sydney Morning Herald* on the subject, the Admiral said that the engineers of the flagship gave it a good trial. He found that it was entirely free from smoke—manifestly a great merit—but it did not give the same good results as were obtained from New South Wales coal. Nevertheless, from a naval standpoint, it was highly valuable to know that coal so good as the "Collie" was available at Fremantle.

The Railway Department of Western Australia uses Collie coal exclusively on its locomotives, and with the best of results. Other State departments have tried the local fuel with equal satisfaction, and the State is now one of the largest customers of the collieries. The convincing tests of every day work have proved that for steaming purposes Collie coal is of very great commercial value.

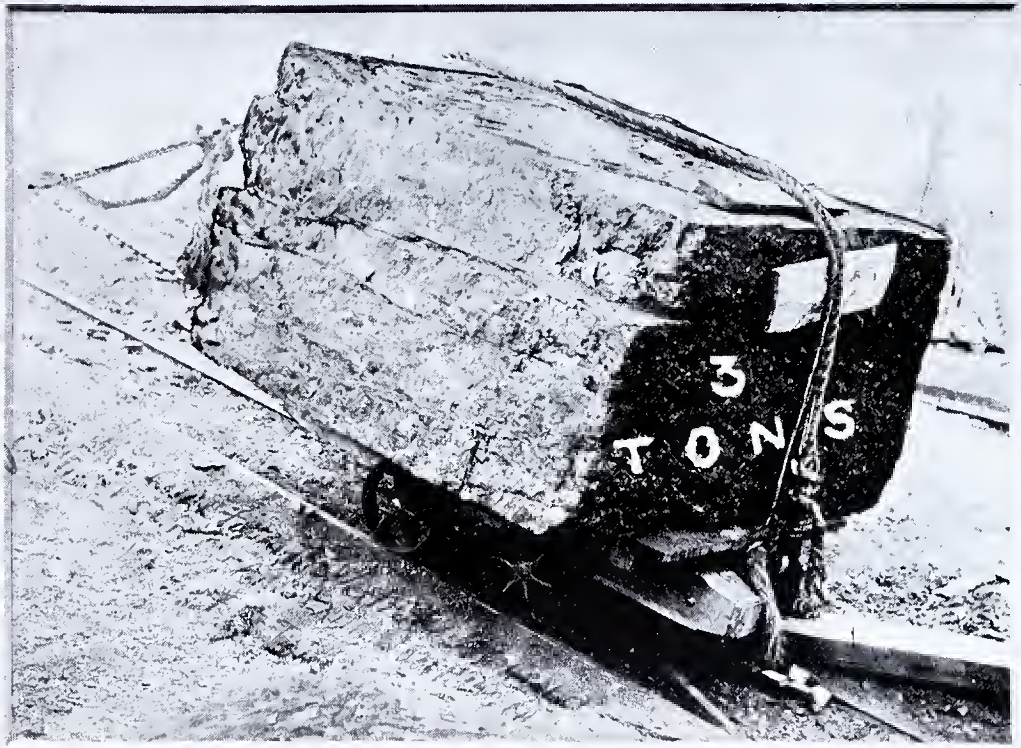
The Naval Aspect of the Question.

It is impossible to overrate the importance to Australia of its having, on its Western shores, a valuable coalfield. In these days, when superiority on the sea is the guarantee of British supremacy, there should be peculiar satisfaction felt by all Imperialists at the fact. The value of the coal for naval purposes seems unchallengeable. A good steaming coal which is smokeless, or nearly so, is, of all coals, that which the Admiralty authorities value the most highly. With a Federal railway connecting the western and eastern shores of Australia, and valuable coal deposits existing at either end, the perfection of defence attainments would seem to have been attained. There is every probability that Fremantle will become, by virtue of its connection with the Collie coalfields, an important coaling centre on the Indian Ocean. The future of Fremantle as an important seaport—one of the most important on the sea-board of Australia—is indissolubly bound up with the progress of the Collie coalfields.

As this coal has now obtained the indorsement of the naval authorities, the natural advantages of Fremantle become more than ever enhanced.

The Future of the Industry.

At this stage of its growth one cannot speak too hopefully of the future of the Collie coal industry. The expansion is most rapid, and its future teems with hope. If the market can be found, there can be sent away from the Collie over a million tons per annum, and more than that if necessary. How is it possible at this moment to assess at its true worth what that means? It spells a large population of wage-earners, a heavy railway traffic, plenty of colliers in the Bunbury Harbour, large settlement on the South-Western lands—in a word, employment and prosperity to a large and self-supporting population. There is no other industry in the Colony which touches so many side issues, and with whose prosperity the well-being of so many other industries is associated.



Block of West Australian Coal,

From the Westralian Wallsend Colliery, Collie Coalfield.

LAND AND LAND SETTLEMENT.

In the South-West Division of Western Australia there are to be found large areas of rich, fertile land. It was long held amongst those who knew the colony only imperfectly, that, from an agricultural standpoint, Western Australia had an unpromising future. It is only of late that the colony's agricultural potentialities have been admitted. And it is safe to say—in view of the successful settlement that is taking place all over the colony—that our agricultural resources are of greater value than has yet been generally recognised.

Wheat-growing.

One of the most important agricultural industries of Western Australia is wheat growing. A very large area is under crop in this cereal, and the average yield is one of the highest in Australia. Until the Coolgardie goldfields were discovered in 1893, there was not much inducement to the landholder to go in extensively for cultivation. Up till then there was a very small population, whose wants were easily satisfied. Later, when the rush of population came along, agriculturists found a splendid market for their produce, and were thereby encouraged to go in more extensively for cultivation. On this account, agriculture may be said practically to have been only commenced in Western Australia in 1894. Since then, as a reference to statistics will show, rapid progress has been made. Signs are not wanting that this—the despised resource of Western Australia—may become at once her most valuable and her longest enduring.

The Wheat-growing Area.

There are no statistics available which will give any information as to the area of land in the colony suitable for wheat growing. Within the fourteen inch rainfall belt, as shown on the Departmental maps, there is a huge area of fertile land, which sooner or later is bound to become changed into wheat fields. Owing to the fact that inferior land is mixed up promiscuously with good, it is impossible to name any exact area as being exclusively suited to wheat growing. Apart from lands already alienated, the area of available good land suitable for wheat growing must be set down at several millions of acres. In this area there are naturally different classes of soil. In all cases the land is more or less heavily timbered, costing from 20s. to £15 per acre before being fit for cultivation.

The Question of Rainfall.

The rainfall is largely the feature which determines the limit of successful agricultural operations in Australia. There are millions of acres of rich, red soil in Western Australia which are so poorly watered that they cannot be used for agriculture, although for pastoral purposes they are widely and successfully utilised.

The Australian continent on the whole is subject to periodic dry seasons, which are felt in their deepest intensity in the

interior. In the case of the South-Western division of Western Australia these droughts are almost unknown. This fact is due to the geographical position of the colony, and to its physical formation. The great rain-carrying winds of Australia come from the west. They invariably strike this colony at the Leeuwin—where the average rainfall is about 40 inches—first in their attack upon Australia. Their influence generally extends northward to the Murchison, over a distance of about 400 miles, and southward well into the Southern Ocean. Parallel with the western coast of Western Australia, and 10 to 20 miles distant from it, runs a range of low hills called the Darling Range. On the coastward side of these hills the rainfall is fairly abundant, varying from 20 to 40 inches per annum. The ranges themselves enjoy a very abundant rainfall, but on their eastern slopes the annual precipitation perceptibly decreases. The valley of the Avon River—the great wheat-growing area of Western Australia—has an annual average rainfall of from 17in. to 18in., but of this the annual rainfall decreases about 10 per cent. for every 20 miles, until the region is reached where the rainfall is of so precarious a nature as to render the land unsuitable for any agricultural process. To the eastward of the Avon Valley, for a space of 70 miles or thereabouts, the rainfall is sufficiently plentiful to enable good wheat crops to be raised. Within this limit a drought, in the sense that it is understood in the eastern portions of Australia, is unknown. There has never yet been a season in these localities where the crops have been a total failure. On the contrary, there have been many magnificent harvests taken from the lands in this area. It has been found that, by careful cultivation, early sowing, the utilisation of a plump and suitable seed wheat, and the employment of a little phosphatic fertiliser, a 20-bushel crop can be grown with a 9in. rainfall.

Cost of Clearing.

The more easterly portions of the colony, in which wheat-growing on successful lines is possible, are the easiest to clear. All the timbers are of the *Eucalypt* type, and in the dry Australian climate burn very readily. In the more heavily watered portions the timber is naturally more dense and solid in its occurrence and therefore more costly to eradicate. In the dry districts, where wheat-growing and grazing are the only possible industries, it is not customary to clear the ground too well. Trees are burnt off to the level of the ground. The soil is then cultivated by means of stump-jumping ploughs, and other such implements, and in course of time the ground becomes quite clean. It is found in experience that little or no inconvenience is experienced in cultivating and harvesting land so prepared. This method of clearing costs from 15s. to 30s. per acre. As a rule clearing is let by contract, and there are invariably numbers of men used to the work willing to undertake it at about these figures. Where better work is desired, or in the case where fruit growing or viticulture is contemplated, the timber is generally grubbed free of roots and stumps to a depth of 8in. or 9in., at a price varying from £2 to £4

per acre. These figures apply exclusively to the areas on the east of the Darling Range. In the coastal regions where there is the heavy rainfall, and the opportunity for intense cultivation, proper grubbing is always insisted on, and costs from £6 to £20 per acre.

The Selectors' Desire.

There are, roughly speaking, two classes of land settlement. There is the wheat-grower and grazier combined, with his large area of easily cleared land, and there is the smaller selector, who wants to grow potatoes and onions and generally embark in intense culture. The would-be settler having decided which class of farming he will adopt, can then better choose the locality in which to commence operations. Should the prospects of the wheat-grower and pastoralist appeal the more strongly to him, then his selection should be made in the comparatively dry districts to the east of the Darling Range. On the other hand, the dairyman, the potato-grower, and the disciple of intense culture will make his home in the coastal districts. Here there are rich swamps, which, on being drained, produce prolifically nearly every known vegetable and root. Here also fruit trees thrive splendidly, and the abundance of good feed and water render dairying highly successful.

Fruit Growing.

While Western Australia is destined to be a great wheat producing country, it is also absolutely true that for purposes of fruit growing a large area of her soil is unequalled. The vine grows luxuriantly in nearly every section of the colony, though naturally giving its best yields in the moderately watered districts. In the opinion of experts there is a bright future before the viticultural industry of Western Australia. Wine making is practised on a small but expanding scale, and there is every guarantee that this enterprise will assume important dimensions. The citron trees do wonderfully in Western Australia. On the slopes of the Darling Range, and in the coastal districts, the orange and lemon attain a rare degree of perfection. The orchards of citron trees yellow with their ripening fruit are lovely to behold, and there is soil and room for thousands of such orchards. The soil with its potentialities is there. It only needs the intelligent industry of man to make it fruitful. But it is only by personal inspection that one may understand the glory of a West Australian orangery.

Apple Culture.

On the uplands of Western Australia, where there is a fair rainfall, and where the balmy sea breezes distribute moisture and coolness, the apple thrives abundantly. In the coastal regions also, and on the slopes of the Darling Range—which constitute ideal fruit-growing land—the apple is seen to great advantage. In the Great Southern country, of which Katanning may be taken as the centre, apple orchards have been planted with much success. There is an enormous area in Western Australia suited for apple raising, and it is only a question of time and population for the colony's potentialities in this direction to become widely availed of.

Other Fruits.

The apricot, peach, and nectarine flourish in Western Australia. The fig tree grows luxuriantly over a very wide area, and bears most delicious fruit. Mulberries ripen to perfection in the fine clear sunshine, while strawberries, cherries and gooseberries in their proper habitats give splendid yields. In fact, there is scarcely a fruit that can be mentioned, that will not readily make its home in some part or another of this great colony. The sub-tropical fruits grow to perfection. The vine flourishes as perhaps it does in few countries. Grapes, large, luscious, and delicious, are common all over the country in summer. Plums, too, can be raised excellent in quality, and abundant in quantity.

Dairying and Pork Raising.

Dairying is one industry that has been neglected in Western Australia. But here again the excuse of a small population and a restricted demand may fairly be pleaded. Now the demands for dairying produce from all parts of the colony are overwhelmingly beyond the capacity of local producers. Every year there is an improvement in production, but so far—and especially in this line—the improvement is not what might have been desired, nor what could easily and readily have been reached. In the coastal region, with its rich flats and swamps, under a liberal rainfall, dairying should be possible to a very wide extent. Time and population—the latter being the most important—will, however, show in no uncertain way what this young country can do in the production of butter and cheese. The rich, luscious grasses, the healthy climate, and prolific soil are factors which will make Western Australia a grand dairying country.

Pork raising is successfully carried out in Western Australia, where wide importations have resulted in the presence of a large number of useful swine of approved breeds. Associated with wheat growing or with dairying, pig raising is attended with handsome profit, while consideration must also be given to the cleansing and fertilising of the land proceeding from the working of pigs upon it. In Western Australia all successful farming is of a mixed nature. It is not advisable for the farmer to have all his eggs in one basket. Thus, with fields in cultivation, pig and sheep raising, egg production and dairying, the farmer has the choice of several sources of making money, and the good and experienced agriculturist utilises them all.

Sheep Breeding.

The great bulk of Australian land is used for pastoral purposes. In Western Australia the rule holds equally good. Millions upon millions of acres of land obtain which produce nutritious, indigenous grasses and shrubs on which stock thrive. The bulk of such land, however, is fit only for grazing purposes, owing to the low rainfall. Such lands are situated in the northern portions of the colony. With experienced management it has been found possible to successfully depasture sheep in country possessing a marvellously low rainfall. Admitting the disadvantages of the rainfall, there are

these undoubted advantages of the type of country under review. It possesses one of the healthiest climates in the world. Practically, disease, either in beast or man, is unknown. The abundance of fine sunshiny weather, and the dryness of the atmosphere, render it almost impossible for disease even to obtain a footing. Then the soil is wonderfully rich. The edible shrubs have a marvellous hardiness, and manage, with even a light rainfall, to furnish abundant nutriment to the stock. Even with a dry spell of two years duration the scrub will still continue to furnish useful fodder. Then when the rains do come in real earnest it is surprising to see how the grass grows. Literally, it may be seen to grow. Ground that to-day is brown and bare as a heavily travelled roadway, in a week or two carries green grass, feet in height and waving like a corn field. Nature knows no transformation scene like it. The rich soil, hot with the accumulated sunshine of months has become a veritable hot-bed, and when the moisture comes the plants generate and leap into full life in a manner impossible to the gardener, and incomprehensible to all who have not seen it. It is in this class of country that grazing is carried on exclusively. With careful management and a knowledge of local conditions, marvellous results can be won by the pastoralist. The merino sheep with its valuable wool thrives in Australia as in no other country.

Local Conditions.

Agriculture is a many-sided science. In every country different methods are employed. Every country, in some places every state, has methods of agriculture peculiar to itself, and successful only in that place. So in Western Australia agricultural methods are necessary that are unknown in older countries. Every intending settler should bear this fact in mind. He is coming to coax nature into prolificness under conditions that he never knew before. If he attempt to till land in this country by the methods he has successfully adopted in his own, disaster will almost of a certainty overtake him. If possible, the new settler should put in twelve months working on various farms in the locality where he proposes to settle. He should place whatever money he may have brought with him into the bank. He should then apply himself vigorously to working on the different farms. If he is at all suitable he will find plenty of work at remunerative wages. In this way he will acquire a knowledge of local conditions that will prove of inestimable value to him. He will avoid making mistakes that might have absorbed all his capital, and he will gain a knowledge of market conditions and trade customs, without which he would be seriously handicapped in starting life as a producer. The temptation to make a start at once will be strong, but it should be overcome. Let the motto of the new settler be "make haste slowly," and success will attend his efforts.

Unsuitable Settlers.

In a young country like Australia there is no home for the purely ornamental man, or the specialist. The wealth of the country is in the land, and it has to be dug out before it becomes

negotiable. Willing arms and bold hearts are wanted for this work. To clerks, and tradesmen, and persons of that class, the colony offers little or no inducement. But of *bonâ fide* agriculturists our supply is lamentably short. For these we can find ample room and will welcome their arrival. Families trained to farm life have a better opening than any others. After having gained local experience they will find many good opportunities to work together as agriculturists. Land is obtained on the easiest of terms, and there is an excellent market for all that can be raised. In a few years on suitable land an experienced family working well together should make a competence. The soil is there, and it has the necessary elements of fertility. It rests with the man to make it yield up its wealth in the form of crops, and thereby make his labour highly remunerative. Success or failure rests with the man. Industry and intelligence will spell prosperity, sloth and stupidity will end in misfortune.

The Market Question.

The question "Who will buy my stuff after I have grown it," is one that the wise agriculturist will ask of himself in considering the advantages offered to the producer by any given locality. This question can be more satisfactorily answered in Western Australia than in perhaps any other country on the face of the earth. On our marvellously rich goldfields a large population is busily engaged mining from the earth large quantities of gold. This population, so far as its food supplies are concerned, is dependent on other districts. The sparse rainfall, and the consequent aridity of the goldfields districts, render it impossible that anything can be grown on them. Here then we have linked by rail to the producing centres a large consuming population. In the North again, the large pastoral areas are dependent upon the wheat growing districts for the large quantities of flour and other produce which they require. Similarly on the Darling Range, and in the heavily timbered coastal regions, the many saw mills with their large labour equipment, call for heavy supplies from the producer. Also the metropolitan areas, where large bodies of people—comparatively speaking—are gathered, contain many thousands of mouths to fill, which call for the result of many producers' efforts. In short, Western Australia with its mineral, timber and grazing resources, all joined together by many miles of efficiently equipped and worked railways, offers an unequalled market to the producer. This fact is one that must not be lost sight of by the intending Australian selector.

Proximity to Europe.

Western Australia is the portion of the continent that is nearest to the old world. The port of Fremantle is from five to eight days nearer to the Mediterranean than is Port Adelaide or Sydney. From Colombo, in Ceylon, Fremantle is about from nine to ten days distant by steamer. When an overland route by rail to India will have become an accomplished fact, Western Australia will be brought in very close touch with Europe. As it is now—

thanks to the excellent steam services that obtain—from Marseilles to Fremantle is barely a 28-days' trip. This time is sure to be improved upon, as the increased population of Australia warrants the institution of a better service. It goes without saying, that, to the intending vigneron, orchardist, or farmer, this geographical advantage of position is a matter of great importance. The day must soon come when Western Australia will export soil products. In the export of apples, fruit, wine, and such commodities, the week's advantage in the duration of the voyage will be of great commercial value to Western Australian producers.

Land Regulations.

In Western Australia the land laws are the most liberal that exist in any country. The great bulk of the land is still owned by the State, which disposes of it to intending applicants on terms of marvellous liberality. The principle of having the State as landlord has worked well in Australia. Under it populous agricultural communities have been settled on the land, and are contentedly occupied in making it wealth-producing. In Western Australia there is a variety of conditions under which land can be selected. First, there is the principle of selection before survey—free selection as it is often called. In this case the applicant applies for a piece of ground and shows the manner in which he wishes to have it granted. There is also the system of survey before selection. In this case the land is parcelled out into suitable sized blocks, and the applicant selects one or more of them. Areas so subdivided are known as agricultural areas. Where practicable this latter system is adopted, it being found that by far the better results are obtained from it. Another broad distinction in the conditions under which land may be held from the State is made between settlers who wish to reside on their land, and those who do not. The State naturally prefers residence, other things being equal, but, as valuable agricultural development is often effected by persons who cannot reside on a given block, a special provision has been made to meet their case.

All lands selected from the Crown for agricultural purposes are termed conditional purchases. That is to say, certain conditions of payment and development are attached to every lease. These having been satisfactorily carried out, a freehold title issues to the owner.

Conditional Purchase with Residence.

In all cases the applicant must be over 18 years of age. Under this clause a minimum area of 100 and a maximum area of 1,000 acres is selectable. Persons of either sex may make application. The land is valued at 10s. per acre, payable by forty half-yearly payments of 3d. per acre, there being no charge for interest. In all cases the applicant, on making his application, pays as deposit half-a-year's rent. Within six months after the lease of the ground is issued the applicant has to personally reside upon the land for at least six months of each year for the first five years. Within two years one-tenth, and in five years the whole of the lease

shall be fenced on the surveyed boundaries. Within ten years improvements to the value of ten shillings per acre have to be effected, half the cost of the exterior fencing being allowable as part of the improvements at the discretion of the authorities. These conditions having been satisfactorily carried out, the title will issue to the purchaser at his expense. The provisions of the above clause apply to conditional purchase applications where the applicant does not wish to reside upon the land. The only difference is that double improvements are required; that is to say, that in ten years twenty shillings per acre shall have been spent in improvements.

Conditional Purchase by Direct Payment.

For larger operations a minimum of 100 and a maximum area of 5,000 acres may be secured on these terms: Deposit, 1s. per acre; balance by four equal payments of 2s. 3d. per acre, payable on the 1st days of January, April, July, and October, respectively, so that the whole amount is paid for in 12 months. Within three years the whole of the land must be fenced on the surveyed boundaries, and within seven years improvements to the value of 5s. per acre effected.

Garden and Orchard Lots.

Small blocks for gardens and vineyards may be obtained on these conditions: Minimum area five acres, maximum fifty; price of land 20s. per acre; deposit, ten per cent. on application, balance in three years by six half-yearly payments, without interest. The improvements required are, that the land be fenced on its surveyed boundaries within three years, and that, within the same period, one-tenth shall be cultivated as a vineyard, orchard, or vegetable garden.

Grazing Leases.

Inferior lands are selectable under these clauses. They are divided into second and third-class lands. In second-class land a minimum of 1,000 and a maximum of 3,000 acres is selectable. The purchase is effected by making sixty half-yearly payments of one penny and a quarter per acre, and carrying out the following improvements:—Within two years one-tenth, and within five years the whole of the land to be fenced on the surveyed boundaries; within fifteen years further improvements to the value of 6s. 3d. per acre to be effected.

In third-class lands the purchase is effected by making sixty half-yearly payments of three-quarters of a penny per acre. The improvements require one-tenth in two years, and the whole in five years to be fenced, and a further expenditure of 3s. per acre in fifteen years. In grazing leases the applicant must also pay half the cost of survey in ten half-yearly instalments.

Free Farms.

Free farms, not exceeding 160 acres in area, are granted under exceptionally advantageous conditions. The applicant must be over 18 years old, must not own more than 100 acres of land, and in the case of a female must be the head of a family. A deposit of 20s. is demanded as a guarantee of *bona fides*. Within six months

Public Library and Museum, Perth.

of receipt of the occupation certificate the selector is to take personal possession of the ground, and reside upon it at least six months in each year for five years. Within two years one of the following improvements must be effected :—The erectiou of a habitable home, worth not less than £30, the extension of an equivalent sum in clearing or cropping, or the planting of two acres of orchard or vineyard. Within five years one-fourth of the land is to be fenced, and one-eighth to be cleared and cropped. By seven years the whole must be fenced, and at least one-fourth cleared and cropped. The title then issues to the applicant on payment of survey fees and cost of title. Thus the selector becomes the owner of a valuable block of land on the easiest conditions of land tenure that are known in the world. Think of it! One hundred and sixty acres of rich, fertile land for nothing, no rent to pay, only certain improvement conditions to be fulfilled, in the performing of which the applicant is rendering his estate wealth producing!

Working Men's Blocks.

Carrying the principle of State landlordism to the circumstances of the working man, the system of working men's blocks was established. Under these conditions the artisan, earning his livelihood in a town, may take up a residence area of not more than half-an-acre on the goldfields, or five acres elsewhere. The lease is granted for 10 years, payable in 20 half-yearly payments of 1s. per acre. The applicant must make the block his usual home, or that of his family. Within three years the block must be fenced, and in five years improvements must be effected on the land to the value of £2 per acre, in addition to the house and fence. The title then issues under the usual conditions.

Residential Areas.

Under this system of land tenure an even more liberal offer is made to the workers of the colony. On the goldfields this system of land tenure is proving most popular. It is unique in the history of land tenure. What the free farm is to agriculturists, the residential lot is to the townsman.

Under these regulations land declared open for selection as residential lots may be taken up on these conditions: A deposit of 10s. with every application is required. On the granting of the application a lease for 21 years is issued at a yearly rental of 10s. for the lot. Every lot so held must be the habitual abode of the lessee or his family for at least six months in every year. The lot is purely for residential purposes. It is forbidden to use it for business purposes. The lot does not become freehold. Lots may be transferred subject to the sanction of the authorities on a payment of 5s. The minimum area is one quarter of an acre, the maximum five acres.

Agricultural Bank.

A novel, but extremely valuable institution in Western Australia is the Agricultural Bank. Its object is to grant advances to land owners—be they freeholders or only conditional purchasers—against approved improvements. Before any applications will be

entertained it is required that the block—on which an advance for improvements is sought—be fenced. The manager then inspects the holding, and having decided upon the cost of the improvements proposed to be effected, generally recommends that one-half that amount be advanced as the improvements are effected.

Thus the holder of a conditional purchase block of 200 acres finds he will not be able, without assistance, to clear the land ready for cultivation. He therefore fences the block on the surveyed boundaries and makes application for a loan. We will suppose he is in one of the wheat-growing areas, where clearing costs about £3 per acre. The manager will allow £3 for clearing, and about £1 for breaking up the land and root picking, or a total of £4 per acre. As the work of clearing and breaking up proceeds, the applicant receives £2 per acre. The other £2 he has to find himself. To secure the Bank, the applicant transfers his property with all improvements, to it.

The loan is repaid in this manner. For the first five years the applicant pays interest only at the rate of five per cent. per annum. For the next twenty-five years a sinking fund of four per cent. comes into operation, so that at the end of thirty years the whole of the loan, with interest, will have been paid off. This institution has been most successful during the six years it has been in existence. It has been largely availed of, and through its instrumentality thousands of acres of land have been cleared which otherwise would have remained in their native state.

Facilities to Intending Selectors.

The Lands Department has a well organised system of local land agents, whose duty it is to put the intending applicant in the way of seeing any land that he may desire to select. At various points the visitor will find land agents with local knowledge, who will supply him with every information as to the lands of the district. Arrangements have also been made by which the selector can be driven about to see lands available for selection. Further details of the land regulations of the colony and literature bearing thereon are procurable from the Under Secretary for Lands, Perth, or the Agent General for Western Australia, 15 Victoria Street, Westminster, London.

THE SOUTH-WEST DISTRICTS.

For intending settlers, the South-West portion of West Australia offers more advantages for general farming than any other portion of the Colony, having a good rainfall, varying from 20 inches to nearly 50. The climate is good all the year round, not suffering from extremes of either heat or cold. Throughout the summer, although the days are fairly warm, not hotter nor as hot as the climate of Southern Europe, the nights are cool and pleasant, caused by Southerly and South-Westerly breezes that come up about 2 or 3 o'clock every afternoon. Even on the hottest days, the heat is not heavy and muggy, but clear and dry, and there is a total lack of that oppressive heat so often found in hot countries near the seacoast. In winter it is exceptional to have a heavy, or so-called

heavy, frost, the thermometer rarely going below the 1° centigrade, while the average winter temperature is about 15° to 16° centigrade.

The soil varies much in character, from sand and sandy loams to clay and clayey loams, and suitable soils can be easily found capable of growing any kind of fruit or vegetables not requiring an absolutely tropical climate. The country rises gently from the sea-coast to the foot of the Darling Ranges, and, as one goes further South, creeks, swamps, and springs are more plentiful.

Those desirous of an extra cool climate can obtain it in the ranges, where, in the valleys, patches of the richest land is often found, and where the strawberry, gooseberry, raspberry, cherry, etc., grow luxuriantly.

On the gentle sloping lands for about 100 miles South of Perth the timber is fairly light, and the clearing of the land not expensive, but as we get into the hilly country the timber becomes heavy, and the clearing more costly; but in this latter country, artificial grasses thrive all the year through, and for root-growing and dairying it can hardly be excelled. A peculiar and extremely valuable feature of this South-West country is the great chain of swamps that run for over 100 miles parallel with the coast, but at a distance of some miles from it. These swamps are mostly dry in summer, or, if not, are generally easily drained, and the soil in them is of the richest alluvial deposit and retains the moisture all the summer through, so that summer crops of potatoes, onions, and all other varieties of roots can be grown without irrigation. Potatoes planted early in summer yield large crops, one lot of nine acres yielding 17 tons to the acre last season without any manure being applied.

Cabbages, kale, and all vegetables grow to a tremendous size, and yield a green supply all the season through. The following crops grown throughout the whole South-West district:—Wheat, oats, rye, barley, maize, sorghum, lentils, peas, beans, vetches, millet; all the varieties of the melon tribe; potatoes, mangels, beet, turnips, swedes, kohl-rabhi, cauliflower, cabbage, kale, borecole, parsnips, carrots—in fact, every kind of vegetable.

Most of the dairying of the Colony is done in this district; although not on any large scale as yet, it is rapidly increasing, as there are millions of acres of what will be splendid pasture land open for selection, and where at the present there is one head of cattle, in years to come there will be hundreds. Cheese and butter factories are being established, and all the farmers will have to do is to send their milk or cream to the factory and the work is done there.

Bee-keeping is also a very profitable undertaking, the climate being mild; the bees work all the year through and do not need feeding in winter, neither do the hives require protection from the cold. All kinds of fruit trees do well and bear heavily.

Nor is the country without its attraction to the sportsman, kangaroo-hunting with dogs being most exciting; or, for those who prefer it, stalking the kangaroo with the rifle in the forests or through the ranges will be found as good sport as deer-stalking in

Europe, and with better bags as the result. Duck of various kinds, wild geese and swans, the Great Bustard or wild turkey—this bird is generally stalked with the rifle and is a noble bird, weighing up to 30lb., and the flesh most delicate—quail and wild pigeons. In the sea, estuaries, and rivers heavy takes of fish are to be had with little trouble. Horses are plentiful and cheap, and almost every little village has its racecourse. In the larger towns or centres of agriculture are the great annual shows of horses, cattle, sheep, pigs, poultry, and all kinds of produce, where the settlers for 50 or 60 miles around attend.

The country is well opened up with railways, and there are good ports along the coast in communication with all parts of the world.

The area under crop in Western Australia increases annually, in some years doubling the acreage of the year previous in several lines. The following table will show clearly and concisely the results achieved in the last 10 years:—

Year.	Wheat.	Oats.	Barley.	Maize.	Potatoes.	Hay.	Fruit.	Total Area under Crop.
	acres.	acres.	acres.	acres.	acres.	acres.	acres.	acres.
1889-90	35,507	2,075	5,475	80	462	25,704	3,127	73,408
1890-91	33,820	1,934	5,322	81	511	23,183	4,165	69,678
1891-92	26,866	1,302	3,738	23	532	28,534	2,577	64,210
1892-93	35,061	1,695	3,666	33	529	35,124	2,829	79,605
1893-94	42,673	2,571	3,603	37	630	29,590	3,683	83,714
1894-95	21,433	1,635	1,949	27	703	49,896	4,871	81,328
1895-96	23,241	1,880	1,932	23	668	63,804	5,516	97,821
1896-97	31,488	1,753	1,903	30	720	69,436	4,687	111,738
1897-98	38,705	1,677	1,693	243	1,361	80,938	5,577	133,182
1898-99	75,031	3,072	2,185	110	1,675	79,223	6,637	171,776
* 1899-1900	96,478	6,102	4,581	...	3,281	65,380	...	...

* Estimated.

The yield of some of the principal crops for the last 10 years as shown below will, with the table just given, show the effort made to meet the needs of an expanding market with a locally grown supply:—

Season.	Wheat.	Maize.	Oats.	Barley.	Hay.	Potatoes.	Rye.	Dry Peas.
	bushels.	bushels.	bushels.	bushels.	tons.	tons.	bushels.	bushels.
1889–90	504,902	1,017	42,545	92,877	24,394	1,891	*	*
1890–91	467,389	1,526	38,791	85,451	25,014	1,900	*	*
1891–92	265,852	344	20,328	40,745	24,109	1,729	*	*
1892–93	406,350	719	31,534	54,450	40,880	1,937	*	*
1893–94	520,198	573	47,603	47,329	34,196	2,309	*	*
1894–95	170,351	756	20,246	14,921	38,456	2,545	*	*
1895–96	180,077	600	19,326	18,691	53,758	2,290	*	*
1896–97	243,928	504	18,871	12,816	50,500	2,089	*	*
1897–98	408,595	4,826	29,266	23,423	75,464	4,270	2,917	1,082
1898–99	870,909	1,365	55,854	29,295	77,297	5,698	4,812	2,421

* No information available.

Perth Railway Station.

The average yield per acre of the chief products will amalgamate the information of the last two tables, and is as below:—

Season.	Wheat.	Maize.	Oats.	Barley.	Hay.	Potatoes.	Rye.	Dry Peas.
	bushels per acre.	bushels per acre.	bushels per acre.	bushels per acre.	tons per acre.	tons per acre.	bushels per acre.	bushels per acre.
1889–90	14·22	12·71	20·50	16·96	0·95	4·09	*	*
1890–91	13·82	18·84	20·06	16·06	1·08	3·72	*	*
1891–92	9·90	15·11	15·62	10·90	0·84	3·25	*	*
1892–93	11·59	21·78	18·61	14·85	1·16	3·67	*	*
1893–94	12·19	15·40	18·51	13·14	1·16	3·67	*	*
1894–95	7·95	27·49	12·39	7·66	0·77	3·62	*	*
1895–96	8·09	26·07	10·28	9·67	0·84	3·43	*	*
1896–97	7·75	16·66	10·76	6·73	0·73	2·90	*	*
1897–98	10·56	19·84	17·44	13·83	0·93	3·14	8·51	15·88
1898–99	11·61	12·38	18·18	13·40	0·98	3·40	9·36	14·43

* No information available.

In 1898-99, there were 780 acres of land under irrigation, employing 71 pumps, 89 windmills, and 25 water lifters.

In the same period the Colony produced 264,640lbs. of butter, 704lbs. of cheese, 115,338lbs. of cured bacon, 33,929lbs. of ham, and 851,519lbs. of pork, salted or pickled.

Ensilage amounted to 834 tons. Beehives, 2,586 in number, produced 47,487lbs. of honey and 3,205lbs. of beeswax.

Poultry farming has its advocates, for we find on 31st December, 1898, the Colony possessed 257,018 fowls, 32,221 ducks, 2,421 geese, and 4,733 turkeys.

Farming employs 6,359 males and 780 females. Dairying employs 218 males and 329 females. Orchards and vineyards employ 780 hands. Pastoral pursuits employ 1,584 whites and 4,157 male and female aboriginals, making a total of labour on the pay roll of 11,160 males and 3,357 females; in all, 14,217 persons.

The value of agricultural, pastoral, dairying and irrigation machinery, implements, etc., in use, amounts to £313,673.

There are 48 agricultural associations, societies, and clubs, three horticultural societies, and six vine and fruitgrowers' associations.

BREAD STUFFS.

As the present season only terminates on the 1st March, statistics dealing with the current year are estimated only.

The apparent requirements for the present year from outside sources have been computed at 581,986 bushels. It appears that, since 1896, the home production of wheat per head of mean population has increased from 1·53 to 5·15 bushels, and the apparent deficiency has, during the same period, decreased from 7·54 to 3·45 bushels.

With reference to our probable requirements of wheat or flour from outside sources for the year just ending, it would appear that the apparent quantity of wheat required for food, say, $7\frac{1}{2}$ bushels per head of population, would be 1,485,000 bushels. Could it therefore be taken for granted that the whole amount estimated, 96,478 acres, will be harvested, as intended, for grain, it will require a yield of $15\frac{1}{2}$ bushels to the acre to cover the total requirements of the Colony. As, however, it is unlikely such a high average will be attained—last year's average being $11\frac{1}{2}$ bushels—it is not probable that the present year will see the Colony self-supporting, as far as its bread stuff requirements are concerned.

The following table will show how rapidly local supply is meeting demand in this line:—

Season.	Wheat produced in Colony.	Home production. Bushels per head.	Apparent deficiency. Bushels per head.
	bushels.		
1896	188,077	1·53	7·54
1897	243,928	1·57	6·49
1898	408,595	2·41	6·11
1899	870,909	5·15	3·45

Rate of Wages.—The average rate of wages on farms and stations, reduced from returns from all parts of the Colony, is as under. It must be remembered the figures given below vary higher or lower in different districts.

N.B.—The figures in parentheses refer to "Not Found," the others to "Found":—

Ploughmen, per week, £1 2s. 6d. (£1 17s. 6d.); orchard and vineyard hands, per week, £1 (£1 15s.); hand mowers, per week, £1 2s. 6d. (£1 17s. 6d.); hand mowers, per acre, not found, 6s.; hand reapers, per week, £1 2s. 6d. (£1 15s.); hand reapers, per acre, not found, 10s.; hand threshers, per bushel, not found, 6d.; general farm labourers, per week, £1 (£1 12s. 6d.); married couples, per annum, £70 (£90); dairymaids, per week, 12s.; other female servants, per week, 10s.; stockmen, per annum, £52 (£68); boundary riders, per annum, £45; bullock drivers, per annum, £55; sheep drovers, per annum, £40; sheep washers, per week, £1; shearers, per 100 sheep (£1 2s. 6d.); shepherds, per annum, £40; teamsters, per annum, £52 (£80); bush carpenters, per annum, £65 (£104); hut keepers, per annum, £25; men cooks, per annum, £45; generally useful men, per week, £1 (£1 10s.).

THE PASTORAL INDUSTRY.

HISTORY AND NOTABLE INCIDENTS.

(By A. R. Richardson, late Commissioner for Crown Lands.)

To the early pioneer settlers who, leaving the fertile shores of Merrie England in the year 1829, or perhaps late in 1828, with ardent hopes that in Western Australia they would discover a large and freer expanse of those fertile pasture lands which in England had become the privilege only of the opulent and wealthy to occupy or possess, that which met their eyes on landing at Clarence, some 10 miles South of Fremantle, after a long and wearisome voyage of many months, must have rudely disappointed their hopes and greatly disheartened them. The considerable belt or fringe of scrubby limestone hills occurring in that locality must have been the very reverse of gratifying to the practical and experienced eyes of colonists whose knowledge in agricultural and pastoral matters had been acquired among the grassy hills and dales of fertile England. It is no doubt somewhat unfortunate, that before reaching anything like good pastoral country in the Southern districts near Fremantle, the settler had to penetrate a considerable fringe of what in its natural state is somewhat uninviting and unpromising, though a more material experience has taught that, with labour applied in clearing and cultivating, a fair proportion of these unpromising looking localities can be made productive both for pastoral and agricultural objects. Nevertheless, it must have required stout hearts and persevering spirits among the earliest settlers to penetrate some miles of indifferent looking land, exposed to the dangers and uncertainties of a totally uncivilised country, where the black savages constituting the native population were the reverse of friendly, and were disposed to jealously resent the intrusion into their hunting grounds of the white stranger. But the material of which many of these early settlers was built was both stout and tough, and not easily intimidated by difficulties, and so we find they finally succeeded in reaching areas of better land and more fertile pastures in the districts of York and Toodyay, some 60 to 90 miles from Perth. Even there, and more especially along the route, they met with patches of the deadly poison plant, and dismay must have overcome them when they found their valuable beasts of burden and sheep and cattle, after crossing a strip of this plant, dying from its effects. Fortunately it only occurs in strips, and being confined to certain localities, local knowledge and experience taught the early settlers to recognise and avoid the localities in which the poison plant prevailed.

Owing to the absence of historical records relative to the doings of our earliest pastoralists, reliable information is not

easily obtained; but from conversation with some old pioneer settlers we learn the earliest beginnings in sheep husbandry in the Eastern districts consisted of a small flock of 300 pure Merino ewes, imported from England, and which, no doubt, on their arrival in Western Australia, must have been regarded as a very precious possession. These valuable sheep were driven over the Darling Range by those early pioneers, Messrs. R. H. Bland and Arthur Trimmers, assisted on the road by Mr. Walter Padbury, then but a boy. Shortly aft-rwards, this party was followed by the Burges Brothers (William, Samuel, and Lock), and a little later by members of the Parker family, all of whom settled in the York district in the very early days of Western Australian history. But though our early pioneers found in those Eastern districts around York and Toodyay considerable areas of pastoral lands, yet some of them do not appear to have been quite satisfied, parts of the country being much intersected and broken by frequent and occasionally large areas of poor land. A few years later some of the more venturesome spirits, among whom we find the names of the Burges Brothers and Thomas Brown prominent, journeying further afield, discovered considerable belts of good grazing land some 200 miles North, in the neighbourhood of what is now known as Geraldton and the River Irwin, upon which they settled and increased their flocks and herds, as also did the settlers about Toodyay and York; though, owing to the drawbacks and difficulties attending the settlement of the new country, the progress and development were somewhat slow. It has to be admitted that Western Australia previous to the year 1866 occupied but a very unimportant position among the Australian colonies as a pastoral country, for the total number of sheep depasturing within her boundaries up to that time was less than half a million, and about 40,000 head of cattle. The actual numbers of live stock, taken from departmental statistics, were as follow:—

Year.	Sheep.	Cattle.	Horses.
1829	1,469	204	57
1839	20,829	1,394	382
1849	141,123	11,995	2,365
1859	234,815	30,990	8,386
1866	481,040	41,323	16,561

No doubt the chief factor in the progress and development as a pastoral country about this time was the bold and somewhat venturesome efforts of a hardy little band of pioneer settlers who, between the years of 1863 and 1868, resolved to sail away North with their little flocks, and attempt the then extremely hazardous undertaking of settling on the pastoral lands reported to exist North and East of the North-West Cape and Exmouth Gulf, in latitude 22° to 20° North. This new departure was the outcome of the discoveries resulting from the explorations in North-Western Australia, carried out under the leadership of a surveyor in the service of the Western Australian Government, named Francis T. Gregory, in 1861. Acting under instructions from the Western Australian Government, and having been placed in charge of

East Wing, Public Offices, Perth.

a small exploring party consisting of eight men and 20 horses, Mr. Gregory shipped with the necessary outfit, stores, and equipment, in a little schooner named the "Dolphin." The names of this small band were, in addition to the leader, Mr. Maitland Brown, the present Resident Magistrate at Geraldton, then a youth of 20 years; Mr. Shakespeare Hall, who for many years remained a highly respected settler in the land and district discovered by his party, and was also manager of the second sheep station formed in the district; Mr. E. Brockman, son of one of Western Australia's earliest and successful settlers; Mr. P. Walcott, volunteer for the collection of specimens of natural history and botany; Mr. J. Turner, assistant and storekeeper; Mr. J McCourt; Mr. J. Harding, afterwards murdered by natives at Roebuck Bay; and A. James, farrier and assistant.

After safely, though not without many difficulties and risks, landing on the 11th May, 1861, at what afterwards became known as Nicol Bay, in latitude 120° 40′, this little party explored and made known some hundreds of thousands, or rather millions, of acres of previously unknown country; traversed, plotted, and laid down in thoroughly reliable plans and charts, the course of Rivers Maitland, Harding, Sherlock, Yule, DeGrey, Oakover, Fortescue, Ashburton, &c., &c.; and during their six months exploration traversed many hundreds of miles of country. On their return to Fremantle and Perth they reported the existence of very considerable areas of well-grassed pastoral country, suitable for either sheep or large cattle. This intelligence evidently made an impression on the active mind and enterprising spirit of one of Western Australia's worthiest and most intelligent settlers, Mr. Walter Padbury, and so we find him, in the early part of the year 1863, vigorously completing all the necessary business arrangements, purchasing live stock, chartering a vessel, and engaging a party, with the object of acquiring a lease from the Government of a considerable area of this new country, and placing sheep and cattle upon it. All arrangements being completed, we find a little band of pioneers sailing out of Fremantle, on the 23rd April, 1863, in the barquette "Tien Tsin" (about 350 tons), with 370 ewes, 7 horses, and a team of working bullocks. Mr. Padbury himself accompanied them, with three other white men, Charles Nairn, as manager, and six native prisoners from Rottnest, lent him by the Government. After a voyage of about a fortnight they landed safely in what was then known as Butcher's Inlet—now Cossack Harbour—and Mr. Padbury returned to Fremantle in the "Tien Tsin," which was commanded by Captain Jarman—the first mate being W. Butcher, afterwards for many years pilot at Albany Harbour. Mr. Padbury immediately arranged for and despatched a second shipment of 700 ewes and other stock, which after being landed were all taken overland by Chas. Nairn and party, some 170 miles further Eastward on to the DeGrey River country. In the latter part of the same year, 1863, the late Mr. John Wellard, also an enterprising and highly respected settler, and a well-known figure in those days, chartered

the same vessel, and in person took up a shipment of sheep, cattle, and horses, leaving them in charge of Mr. W. S. Hall, who had formed one of Gregory's exploring party. A few other parties from Western Australia followed, amongst the names of whom are John Withnel, another brave and staunch pioneer of the right stamp, and he was accompanied, even in those early days of dangers and hardships, by his young wife, Emma Withnel, who proved herself quite the reverse of a hindrance to pioneer effort and duties, being equal to all the calls, duties, or dangers of bush life and hardship. Then followed others, amongst whom were Viveash, Middleton, Lockyer, and Chas. Harper, the latter afterwards for many years a member of the Legislative Assembly of Western Australia, and at present (1899) the Chairman of Committees in that branch of the Legislature.

But previous to most of these last-mentioned arrivals, a new element appeared on the scene of these early pioneer efforts, in the shape of a few parties and direct shipments of live stock from Victoria, first of whom was what was then known as Mount, Orkney, and Smith's Company, Mr. L. L. Mount in charge, who, after taking up runs on the DeGrey River, adjoining Mr. W. Padbury, afterwards sold out. Next followed the company known as "The Portland Squatting Company," consisting of five working shareholders, the names of most of whom are still well known in Western Australia. The manager was Mr. A. E. Anderson, the sub-manager, Mr. McKenzie Grant, afterwards a member of the Legislature of Western Australia, and more recently better known as proprietor of Newmarracarra, near Geraldton; while the others were Mr. J. E. Richardson, now of Claremont, a member of the Legislative Council; Mr. A. R. Richardson, now of Lowlands, Serpentine, afterwards a member of the Legislative Assembly for 10 years, and Minister for Lands for about three years in Sir John Forrest's Ministry; and Mr. John Edgar. The only two survivors at present are the brothers J. E. and A. R. Richardson. This company originally took up and settled what is still known as the Pyramid, 30 miles S.E. from Roebourne. Following them within a few weeks came one of Victoria's earliest settlers, Mr. J. N. McLeod, with a shipment of sheep, cattle, and horses, and whose son, Donald N. McLeod—now living in Victoria and a member of the Legislative Assembly there—after his father's return to Victoria, remained for some years in charge of the stock and station on the Maitland River. Next arrived an instalment of rather a large pastoral company or association, known as the Denison Plains Company, which, with a large and important shipment of high class stock (sheep, cattle, and horses) from Melbourne, Victoria, in the ship "Warrior," had intended to land at Camden Harbour, and occupy a large tract of fertile land known as the Denison Plains, reported by explorer Augustus Gregory to exist some distance inland from Camden Harbour. It should be mentioned here that some year or so previous to this a pastoral settlement had been established at Roebuck Bay (though afterwards abandoned) through

the efforts and enterprise of Mr. (afterwards Sir) F. P. Barlee, K.C.M.G., then the Colonial Secretary of Western Australia, but the ship "Warrior" running short of water supply for her stock, decided to land the party at Tien Tsin Harbour, that being the port of disembarkation of most of the shipments already alluded to. Amongst the names of many other worthy and resolute colonists who landed in the "Warrior," we find that of Mr. (now Hon.) H. W. Venn, who remained a settler in the district for some 12 years, and later in life became the member for Wellington, S.W. District, and Commissioner of Railways and Director of Public Works for some six years in the Forrest Government, and still member for Wellington. Other shipments followed, both from Victoria and Fremantle, and these formed the foundations of the pastoral industry in the more Northern portions of Western Australia. In more recent times, but only a few years later, other explorations were undertaken.

One important expedition, which gave the impetus to the pastoral settlement up the Murchison River, and between there and the Upper Gascoyne, was under the leadership of Mr. (now the Right Hon. Sir) John Forrest, P.C., K.C.M.G., the Premier of the Colony, who at that time was in charge of a party pushing their way through unknown country to the South Australian border. Later still his brother, Mr. Alex. Forrest, also a member of the Legislature, took charge of a party to penetrate from the DeGrey River to Port Darwin. Owing to the rugged, impossible country met with in the Leopold Ranges, Mr. A. Forrest detoured and proceeded up the Fitzroy River, thence to the South Australian border, and up the telegraph line to Port Darwin, his discoveries resulting in the pastoral settlement of the West and East Kimberley districts. These and other less public explorations by pioneer settlers themselves, and through also the knowledge gained previously of the existence of pastoral country on the Gascoyne from the expedition of Surveyor F. T. Gregory—who had visited and explored that river previous to his trip to Nicol Bay—resulted in pastoral settlement and developments, working right away from Geraldton to the Gascoyne, and thence gradually right through to the Ashburton River, thus meeting in a way the settlement from Nicol Bay, travelling South. A separate branch of settlement also began in the Kimberley District about this time.

A further important development of the pastoral industry in the North was no doubt due to the hardy efforts and enterprise of Mr. E. T. Hooley, until recently manager of Dalgety & Co.'s business, and later a member of Parliament, who in the year 1866 undertook and successfully carried out the task of driving several thousand sheep overland from Champion Bay (Geraldton) to the Ashburton River, a distance of about 700 miles. As this route had not been previously explored, and the question of finding water along the route was quite problematical, wild natives occupying the country all along the route, it ranks as a notable undertaking; and

its success marked a new departure and opened up considerable possibilities for the Northern districts, as from that time forth sheep and cattle, instead of being imported by the very expensive method of freighting in sailing vessels (steamers in those days and for some years afterwards being quite unknown on the coast), were travelled overland from the older settled districts of the Colony, thus stocking up the various runs and stations then being formed between Geraldton and the DeGrey River. Hence the occupation and settlement of the country in the Gascoyne and Roebourne districts became more rapid, the number of sheep having risen from less than half-a-million in 1870 to $2\frac{1}{2}$ millions in 1890; and cattle from some 4,500 to some 130,000. But it is since the year 1890 that the increase in cattle has become more rapid, owing to the formation of purely cattle stations in East and West Kimberley, considerable herds having been brought over the border, both from the Northern Territory, South Australia, and from Queensland. Though these importations, during the last four years or so, received a sudden check and stoppage, owing to the prohibitive enactments rendered necessary by the introduction of the cattle tick from the Northern Territory and Queensland, yet the numbers now are so considerable that the natural increase from the herds within the colony must be considerable. The number now in Western Australia (1899) is nearly 180,000—not very large, certainly, when compared with a colony like Queensland. But, no doubt, the day is not far distant when the Kimberley districts (East and West) will boast of over a million head of cattle within their borders.

To return to the sheep industry and prospects, it has to be observed that the years following 1890 were not so prosperous or propitious to the increase in numbers, owing to what is known as the great drought of 1890 and 1891, that assailed all the pastoral districts lying between Geraldton on the South, and West Kimberley on the North; though the Kimberley District itself, owing to more regular tropical rains, does not suffer much from droughts. The disastrous results of this drought were that the numbers of sheep depreciated from 2,500,000 early in 1890 to about 1,700,000 in 1892. Even now, writing in 1899, the numbers have barely reached the maximum, though this is chiefly owing to other causes, notably the sudden increase in population of the colony, causing heavy drawing on all surplus and fat stock locally available. In addition to the actual losses in stock the protracted dry weather, intensified by the heat of a tropical and semi-tropical climate, seriously affected the permanent grasses, and it has taken several years of somewhat light stocking to restore them, though in most localities they have now recovered, and look more like their original condition.

As the numbers of either sheep, cattle, or horses do not at present warrant Western Australia in taking a too prominent rank amongst the colonies as a pastoral country, inquirers may desire to know what are her prospects of any considerable increase in these numbers. As a stern disregard of anything like fictitious estimates

The Zoological Gardens, South Perth.

prohibits us from indulging in prophecies more agreeable to the imagination than true to facts, we feel bound to confine our forecast as to the increase in sheep within reasonable limits. We cannot, therefore, hold out the prospect of more than, say, a million increase during the next ensuing seven or eight years, though fortuitous circumstances may arise which may increase our prospects. No doubt any combination of causes operating so as to bring about extension of the railway system inland in the Kimberley District would result in a considerable area of the pastoral country now reserved to cattle being stocked with sheep, as under present conditions the long inland cartage on wool is somewhat prohibitive. Another factor that, with the increase of settlement and population in what is known as the South-West District, will come into activity in the near future by competition, will be the clearing, ringing, cultivation, and improvement of many hundreds of thousands of acres of second and third-class country in the South-Western District. The rainfall in this district is so good that much of the land where the soil is light and somewhat inferior, and which at present is incapable of growing anything but trees and scrub will become pastoral country. It has been proved by experience that when this description of country is opened up, stocked and frequently burnt off in summer, it ultimately becomes converted into very fair pasture country, which, if even not actually the best fattening country, will produce, in the not far distant future, many thousands of bales of wool; and no doubt, by the aid of a little industry and growth of fodder plants, the settlers will contrive to also fatten the stock reared upon it. It is doubtless a most regrettable feature that over the vast areas of land in the districts extending inland from the sea, and over a large area in which gold is found, the climate is so impossible for anything in the way of pastoral and agricultural pursuits; for over considerable areas of this region the soil, given the rainfall, would rear and sustain many thousands, aye, millions, of live stock. Whether science will ever come to the rescue with artificial aid is a question too uncertain to speculate on, more especially as the fact is too well known to practical stock-breeders—though not realised by theorists—that in long droughts in Western Australia the stock seldom die from want of water, but from sheer want of feed, owing to absence of growth.

The prospect of very much larger increases in cattle is more certain, as there can be little doubt that Kimberley will ultimately produce more fat cattle than our own population, or one three times its present numbers, is likely to require for its support.

The history of the pastoral industry, as far as Kimberley is concerned, is closely associated with the names of Connor and Doherty, Durack, Emanuel, McLarty, Alex. Forrest, Panton, and others; and in earlier years, before these gentlemen appeared to take up the pioneering development, much credit was due to the enterprise of a few other early pioneers. Mr. G. J. Brockman, now a large pastoralist on the Manilya River, first ventured on the intro-

duction of a small shipment of sheep, landing them at Beagle Bay, intending to drive overland to the Fitzroy River. Shortly afterwards Messrs. A. R. Richardson and William and George Paterson organised a party (Mr. S. L. Elliott and H. Cornish also becoming members of it), chartered a vessel, fitted her out, shipped a good number of ewes from Fremantle, and landed them also at Beagle Bay, under the working management of Mr. G. Paterson, of Creaton, Pinjarrah. The party finally drove them across overland to the Fitzroy, and formed the first sheep station in the Kimberley District. The Kimberley Pastoral Company followed this example the following season, under the management of Messrs. John and William McLarty, other shipments succeeding soon after. Sheep seem to thrive very well and grow good wool on the Fitzroy River, though they do not appear to have been as yet tried in the East Kimberley District; but ere many years hence we shall surely find the present numbers of both sheep and cattle in the Kimberley District of Western Australia very largely increased.

The terms and conditions under which country for pastoral objects may be leased from the Western Australian Government are fairly liberal. To begin with, in the farthest North, the Kimberley District, the lessee may take up blocks of not less than 50,000 acres, at a rental of 10s. per thousand acres, which, upon complying with mild stocking conditions, is reduced to 5s. per thousand acres, and he has an assured tenure of 28 years from 1st January, 1901. Then for what is known as the North-West Division, extending from latitude 19° on the North, to the Murchison River on the South, and to the 122nd parallel of West longitude, the lessee may take blocks of 20,000 acres and upwards at a rental of 10s. per thousand acres and a tenure of 28 years from 1st January, 1901. Next comes what is known as the Eastern Division, which lies more inland and in which the rainfall is scantier and more uncertain. The rental is only 5s. per thousand acres, other conditions much the same. Within the boundaries of the South-West Division, which is the temperate region enjoying more certain seasons, and in which agriculture is possible, the rental is £1 per thousand acres; but owing to the fact that the land is open for purchase under liberal conditions, there is no security of tenure.

With reference to the present condition as to improvements of the holdings and stations under pastoral tenure, the progress and development already attained are considerable and creditable. With the exception of stations which may have only been occupied a few years, or are perhaps situated a long distance inland, most of the runs are fenced with sheep-proof wire fences, divided into large paddocks, varying from 1,000 to 50,000 acres, but usually from 10,000 to 20,000 acres area. Where there is no natural permanent watercourse the settler has expended considerable labour and expenditure in sinking wells in all his paddocks, the water being raised for the stock either by hand or horse-power or windmills, which last are beginning to come into use and popular favour. The homestead is invariably a fairly comfortable one, plain, but not

expensive; and in the case of the well managed stations vegetable gardens are an important adjunct. All the progressive ones, which are decidedly in the majority, expend, either annually or periodically, a good amount in importing fresh blood, both in rams and bulls.

It should be here stated that very little country beyond the coast fringe, varying from 100 to 350 miles inland, is as yet occupied by the pastoralist as in other colonies; the nature of the soil and the aridness of the climate offering less inducement to settlement beyond this belt until reaching far enough North to be well within the tropics, where tropical rains and thunderstorms can be more relied upon. South of the 19th parallel of latitude the country far inland assumes a somewhat arid and more or less barren aspect, varied in places by patches, more or less extensive, of better country. Pastoralists up to the present have not considered the occupation and settlement of the inland areas profitable enough to justify the considerable initial outlay requisite to establish any important settlement; but in the light of the recent rise in wool values, we may confidently anticipate that pastoral settlement will become imbued with fresh life and vigour, and penetrate further inland than has previously been considered payable. In the event of a transcontinental railway to the South Australian border being undertaken, it will draw pastoral settlement some distance further inland; but from what is known of the country, rainfall, and doubtful and expensive water supply, only moderate expectations are justified, and we should be more disposed to speculate on the possibilities of further gold discoveries cropping up than of any very extensive pastoral settlement. There is also a large and fertile stretch of pastoral or agricultural country known as the Nullabar Plains, inland, and trending N W. from Eucla, but the water supply has to the present formed an obstacle to its profitable settlement and occupation, though it is not unreasonable to assume that where such a considerable and important area of rich, grassy country occurs in such a temperate latitude (being on the Southern fringe of the colony North of the Great Bight) man's ingenuity and enterprise will ultimately be equal to devising methods for obtaining water for the many thousands of live stock which could then be depastured. Though the rainfall in some seasons may not be sufficiently heavy to fill artificial reservoirs by the ordinary natural process of catching the storm water that the ground is unable to absorb, yet it should be quite practicable in these days of skilled manufacture to obtain some kind of cheap material prepared in such a way that it would shed off all the rain that falls upon it, and by laying it down in large sheets on some natural slope result in precipitating the water into prepared reservoirs. By some such means the rainfall that generally falls even in the drier seasons would be found sufficient for all ordinary needs. In conclusion, we feel quite safe in the conviction that the natural developments arising from the industry and enterprise of the colonists and the increase of their flocks and herds, will not only be equal to supplying the food requirements of the present population, but will allow for a considerable increase in the consuming population of the future.

THE WINE INDUSTRY.

One of the most important natural industries of Western Australia is wine making. The area over which vines are successfully cultivated in this Colony is very large. Practically, the whole of the South-West division of the Colony is well adapted to viticulture. Both soil and climate are specially favourable to the carrying on of this industry. Of soils in Western Australia there are many varieties. That of the Darling Range, which is a mixture of finely grained ironstone gravel, mixed with a fair proportion of loam, produces a high-class wine, clean to the taste, rich in colour, and of pleasant bouquet. This soil is healthy, warm, and well drained. Its looseness specially favours root growth. There is also a large area of country in which chocolate-coloured soil abounds. This land is also excellently adapted for viticultural purposes. Generally a genial clay sub-soil is found about eighteen inches from the surface. The surface soil is a finely-coloured chocolate loam, in which fruit trees thrive. There is again a lighter coloured loamy soil, interspersed with fragments of decomposed granite. On this class of soil excellent vineyards have been raised. There are also many sandy soils in Western Australia which have proved most suitable for vine cultivation. With many of them limestone fragments or influences are associated, and in this class of sand the best of results are obtained.

Climate.

According to the rule laid down by the French botanist Boussingault, a temperature above a certain minimum of heat is necessary for the germination of seed, another for chemical modification, a third for flowering, a fourth for the ripening of seeds, a fifth for the elaboration of saccharine juices, and a sixth for the development of aroma or bouquet. The temperatures determined by the same botanist as necessary for the vine are a mean of 59° Fahrenheit during the growing months, and 66·2° Fahrenheit during the months of maturity.

The following table illustrates the advantages of Western Australia as regards the point of temperature. The places mentioned in the right column are well-known Californian fruit growing centres :—

Western Australia.	Deg. Fah.	California.	Deg. Fah.
Geraldton	72·3	San José	66·2
York	76·2	Los Angeles ...	67·8
Perth	72·9	Sacramento ...	71·7
Bunbury	66·6	Fresno	84·1
		Riverside	73·7

A *reference to statistical* records will show that during the summer and autumn months a fine and bright state of atmosphere prevails. The air is, moreover, just suitably dry, and, as a consequence, there is little help to fungoid pests from the climate. It can be safely said that the dry bright atmosphere of Western Australia, and the suitableness of its soils, render it a land peculiarly adapted for viticultural pursuits.

A Clean Country.

Owing to a very strict Insect Pests' Act, which has been rigidly enforced in the Colony for many years, many of the most destructive pests and blights which affect fruit crops in other countries have been successfully kept out of the orchards and vineyards of Western Australia. Phylloxera, black rot, mildew, and other diseases which have ravaged the vineyards of other countries are unknown here. The oïdium of the vine, which is the disease most prevalent, is easily checked by sulphuring. Moreover, care has been taken by the experts attached to the State Agricultural Department to advise the planting of the better vines only. In consequence the average Western Australian vineyard contains little that is inferior.

The Type of Wine.

The director of the Fruit-growing and Viticultural Branch of the State Agricultural Department is Mr. A. Despeissis, a graduate of the Royal Agricultural College, Cirencester, who also holds a certificate from the Laboratory of Fermentation of the National Agronomical Institute, France. Mr. Despeissis had, besides, a special course in the study of Fermentation at the Pasteur Institute, Paris. In addition, he has spent some time in the Bordeaux, the Herault, and the Cognac vineyards, gaining practical experience as a vigneron. Later, he completed his studies in wine making by a season in the large cellars of Gilbey Brothers, the great London wine merchants. According to Mr. Despeissis the following grapes are the best suited to local conditions :—

Red Wine ...	Shiraz of Hermitage Malbeck } of Medoc Cabernet } Morastel from the Pyrenees.
White Wine ...	Riesling White Pinot Pedro Ximenes Verdelho.
Drying... ...	Muscat Alexandria Muscat Gordo Blanco Zante Currants Sultana.

These grapes are procurable locally. The importation of rooted vines is strictly prohibited, and cuttings can only be introduced under stringent regulations.

Table Grapes.

Table grapes of superb quality are raised in Western Australia, and as these ripen when it is winter in Europe it is hoped that presently a valuable export trade will spring up. From trial shipments most excellent results have been obtained. Grapes packed in granulated cork, sent from Albany by mail steamer, have arrived in Southampton, England, five weeks later, in splendid condition. In this way the Muscat of Alexandria and the Almeria have been experimented with. It is expected that equally satisfactory results will be obtained from the Doradillo and the Wortley Hall grape, especially when shipped direct from Fremantle, a port which would reduce the duration of the voyage by two more days. This latter grape by the way is unknown in France. It is as large as a plum, of a purple colour, and in Western Australia is a splendid table grape, being firm and fleshy. From Fremantle to Marseilles by mail steamer is about a 28 days trip. The probabilities are that even this excellent service will be shortened.

Market.

There is a limited local market for wine. In 1899 over one hundred thousand gallons were manufactured locally, and another fifty thousand gallons in round numbers were imported. The vigneron of Western Australia is looking to the consumers of the old world as a market for his surplus product. At present rates of progress the day is not far distant when wine will be exported in large quantities from Western Australia. The State is so impressed with the possibilities of this trade that it has left no stone unturned to build the industry up to the point of perfection. To this end has the importation of vines from other countries been rigidly prohibited—although the State annually imports and rears in its own quarantined nursery approved vines from different parts of the world. To this end also has been due the creation of the Agricultural Department, with its highly qualified experts, who watch over the industry and give advice and instruction to those engaged in it.

Central State Wineries.

The point has now been reached in the viticultural industry of this Colony when a proper system of central wine making becomes necessary. The State has already had the matter under consideration, and it is pretty certain that before long a system of Central State Wineries will be introduced. It is desired that the Western Australian wine designed for export should be absolutely pure, carefully fermented and reared, attractively got up, and constant and unvarying in type. This end can only be achieved by separating the businesses of production and manufacture, as was done in the case of the butter industry, where vast strides would have been impossible without the creamery and butter factory systems. Under the system of central wineries there would be erected at a central railway point an up-to-date winery, managed by a recognised expert. At different points in the country fermenting sheds

would be erected at or near railway stations. The resulting must would be railed to the central winery, where it would be converted into the best article that science and skill could devise. The by-products would also be made of commercial value, instead of being allowed to go to waste as is now the case. The small growers would be saved the cost of erecting cellars, and the trouble of making perhaps an inferior and unsalable wine. On the other hand they would receive an advance on the grapes the moment they were weighed at the fermenting shed, and their raw product would be transformed by manufacture into a valuable and much sought after article of commerce. Whether the central wineries will be erected by the State or not is just for the moment uncertain. The State proposals, it is understood, are to guarantee interest at 5 per cent. on such an undertaking where satisfactorily carried out by private enterprise. Failing a response to these liberal proposals there is no doubt but that the State will step in itself rather than see a valuable natural industry decline.

Magnificent Opportunities.

The future of the wine industry of Western Australia is one of magnificent opportunities. The special benefits of the land laws of the colony are dealt with in another place, but it may here be again repeated that land is procurable from the State on terms of exceptional liberality. Then the industry has grown under the watchful supervision of highly trained experts, whose recommendations have always received official indorsement. As a consequence there is practically no disease in our vineyards, and the varieties of grapes grown are such that high-class wines can be manufactured from them. The soils and the climate are specially adapted to the successful prosecution of the industry, while the accessibility of the markets of the world is a guarantee to the grower that he can readily dispose of his produce. To the vigneron of the old world this new country in the Southern hemisphere offers inviting attractions, especially if he has an industrious family. Many countrymen from European States live in Western Australia and find it a congenial home. Their skill and industry have in many cases won them good and comfortable positions in life, while their own personal worth has made them respected and popular amongst their fellow citizens.

FORESTS OF WESTERN AUSTRALIA.

(Compiled from a Report by the late J. Ednie-Brown, Conservator of Forests, Western Australia.)

INTRODUCTORY.

Copies of the Report of which the following is a Summary, and full information about acquiring Timber and other Leases, etc., and about facilities granted to Settlers and Capitalists, can be had at the Office of the Agent General for Western Australia, London.

Copies of the Report on the Forest Resources of Western Australia, made by direction of His Excellency the Governor of Western Australia in 1882, by the world-famed Australian botanist, the late Baron Sir Ferdinand von Mueller, G.C.M.G., M.D., Ph.D., F.R.S., etc., etc., etc., Government Botanist of the Colony of Victoria, can also be had at the office of the Agent General.

The annual special issue of the *Timber Trades' Journal* for 1898, published in London, contains valuable information about woods imported into Britain from Western Australia. The information includes the following general remarks :—

" Western Australia has found a mine of wealth in her jarrah and karri forests, and is furnishing our cities with the best and most durable paving yet introduced." The detailed report for the year is so very encouraging that we reproduce it in full as follows : —" Jarrah.—This trade has been progressing, and numerous limited companies have been floated for taking over private concessions, and with increased capital working and further developing them for the benefit of all concerned. Most of them took some time to get fairly into swing, and, although through the year the supplies were not equal to the demand, and could not keep pace with it, at the latter end cargoes began to arrive, giving evidence of forthcoming activity. During the time of scarcity advanced prices were paid for landed wood in order to complete existing contracts, but recent arrivals have reduced the strain upon the market, and in all probability the supply will henceforth be equal to the demand. It is now extensively used in the metropolitan area, and is extending to many provincial and Continental towns for paving purposes. Karri, the rival paving wood to the above, has come forward freely, and been in good demand by those who favour the use of it, and we think the patronage of the vestries is generally pretty fairly bestowed. Its durability and strength of

fibre have been strongly demonstrated. Some thirty years ago a ship was built at Rotherhithe on a composite principle, *i.e.*, iron ribs and wood outside planking. The wood used was karri, and after buffeting the waves for all these years she has been taken to a western port and broken up, and the planking has been found sound and fit for wood-paving. It has been cut into suitable blocks, and the streets and roads of the town have been paved with it—a truly remarkable record, that speaks for itself. Of Australian forest mahogany and other hardwoods there were no imports, but several parcels have been placed on trial, and results are awaited."

Within the last three years the British Colony of Western Australia has bounded into a leader among the timber-exporting countries of the world. It is a very large exporter of timber to Europe, America, and India; and there are signs that before long it will also be exporting largely to China and Japan. This has to a great extent arisen from its having made known what it possesses in quantity, quality, and variety of matured timbers. It is gratifying to contemplate the progress which has been made during the last few years, and to observe that the improvement is likely to continue. More particularly in England there has arisen a wonderful demand for Australian hardwoods, which, to a great extent, mean jarrah and karri trees indigenous to Western Australia.

Western Australian timbers seem suitable for out-door constructions all over the world, hence the demand for them; and the great demand for timber leases is explained, apart from the undoubted excellence of the timbers, by the fact that large quantities of the same species of tree grow on considerable areas without any material intermixture of other species. This is of very great advantage to timber cutters, as it tends to lessen very materially the working expenses of removing machinery and other expenses connected with securing large quantities of one particular kind of timber. The timber trees are chiefly gregarious. This is particularly the case with jarrah and karri, although, as a rule, the former is found forming a sort of fringe to the latter, but never *vice versa*. This peculiarity of special habitats for each species of tree is a distinctive feature of the forests of Western Australia, and one of the strong points in the disposal of its timbers.

More than a million acres of forest land are leased from the Government for the purpose of acquiring the timber on it. The forests on it are principally of jarrah trees, and comprise some of the finest forests of that species. The land has been taken up in blocks of from one to more than one hundred thousand acres, and although only a small portion is as yet being worked, the prospects in the near future are immense and will soon reach very large figures. At present there are only some 40 sawmills in full work, but in connection with them the following figures have been collected:—Strength of machinery, 2,254 horse-power; number of persons employed in working the mills, 2,580; number of horses and bullocks employed on the works, 1,847; length of private tramways and railways on the leaseholds, 250 miles. It is calculated that some-

thing like 1-30th of the population of Western Australia is depending on the timber industry, and the number is increasing. Therefore, its forests play a very important part in the welfare of the country.

On the 9th December, 1899, the Registrar-General of Western Australia, by request of the Chairman of the local Royal Paris International Exhibition 1900 Commission, supplied the following as the latest statistical information relative to the timber industry:—

Total number of forest timber mills cutting native timber		35
Horse-power of engines	full	3,980
	actually used	3,925
Average number of persons employed		2,961
Number of bullocks employed		905
Number of horses employed		1,410
Length of private railways and tramways, miles		273
Superficial feet of timber cut		103,042,991
Value of land and buildings		£397,220
Value of plant		£473,758
Value of timber sawn at mill		£602,461

A Department of Woods and Forests has been established, and its general usefulness is beginning to be recognised and appreciated by all interested in the industry.

FOREST TREES.

Western Australia is singularly rich in its flora, and many species are of great value in the commercial world. Perhaps none of the Australian colonies has a greater number of acacias than Western Australia, but its principal trees belong to the eucalyptus family, and many are second to none in worth and durability.

The following is a list of the principal forest flora:—

Genus or Natural Order.	Species or Botanical Name.	Popular Name.
Leguminosæ	Acacia saligna	Wattle
Do. ...	do. acuminata	Raspberry Jam
Do. ...	do. microbotrya ...	Badjong Acacia or Wattle Gum
Myrtaceæ ...	Agonis flexuosa	Peppermint Tree
Proteaceæ ...	Banksia verticillata ...	River Banksia
Do. ...	do. littoralis	Seaside Banksia
Do. ...	do. attenuata ...	Narrow-leafed Banksia
Do. ...	do. Menziesii	Menzies' Banksia
Do. ...	do. ilicifolia	Holly-leafed Banksia
Do. ...	do. grandis	Great-flowering Banksia
Do. ...	do. dentata	Toothed Banksia
Casuarineæ	Casuarina Fraseriana	Sheoaks
Do. ...	do. glauca ...	
Do. ...	do. Decaisneana	
Myrtaceæ ...	Eucalyptus marginata ...	Jarrah
Do. ...	do. diversicolor ...	Karri

Genus or Natural Order.	Species or Botanical Name.	Popular Name.
Myrtaceæ ...	Eucalyptus gomphocephala	Tuart
Do. ..	do. cornuta ...	Yate Gum
Do. ...	do. calophylla ...	Red Gum
Do. ...	do. loxophleba ...	York Gum
Do. ...	do. patens ...	Blackbutt
Do. ...	do. oleosa ...	Mallee
Do. ...	do. rostrata ...	Flooded Gum of the Interior
Do. ...	do. rudis	do. South-West
Do. ...	do. redunca ...	Wandoo
Do. ...	do. decipiens ...	Flooded Gum
Do. ...	do. ficifolia ...	Red-flowering Gum
Do. ...	do. longicornis ...	Morrell
Do. ...	do. salmonophloia	Salmon Gum
Do. ...	do. salubris ...	Gimlet Wood
Do. ...	do. megacarpa ...	Blue Gum
Do. ...	do. pyriformis ...	Red-flowering Mallee
Coniferæ ..	Frenela verrucosa	Cypress Pine
Myrtaceæ ...	Melaleuca Leucadendron ...	Paperbark
Santalaceæ ...	Santalum cygnorum ...	Sandalwood
Loranthaceæ	Nuytsia floribunda ...	Christmas Bush

DESCRIPTION AND PROPERTIES OF THE PURELY COMMERCIAL TREES.

Jarrah (sometimes called Mahogany).

This is, without doubt, the principal timber tree of Western Australia. It is predominant in the extent of its forests, the various uses of its timber. Jarrah and Western Australia are almost synonymous words; and as this has been the case from the earliest days in the history of the Colony, so will it continue as long as a jarrah forest exists. This is no disparagement to the other trees, but simply emphasises the fact that jarrah is the principal indigenous tree. There are others which are equally, if not more valuable in their own spheres, but jarrah timber is foremost for constructions necessitating contact with soil and water.

The botanical name of the tree refers to the thickened margin of the leaves; "jarrah" is the name given to it by the aborigines, and "mahogany gum" is that by which it is popularly known among some of the settlers.

There is nothing particularly picturesque about the appearance of a jarrah tree or a jarrah forest. The general effect *en masse* is dull, sombre, and uninteresting. Except in special spots and localities, the tree is rugged and inclined to be straggling and branchy, unlike karri, which is almost invariably a fine straight tree, comparatively free from branches, except at the top.

In its general appearance, the jarrah tree resembles very markedly the tree known in the other Australian colonies as stringy-bark. The bark is persistent, fibrous, and dark-grey in

colour, but more deeply indented than stringy-bark. It is not uncommon to find considerable areas where many of the mature trees attain heights of 90ft. to 100ft. with good stems 3ft. to 5ft. in diameter and the first branch 50ft. to 60ft. from the ground. Such areas are described as first-class jarrah forests; but on an average a jarrah tree of a good healthy stamp is about 30ft. to 50ft. in height and 2½ft. to 3½ft. in diameter at the base. In fairly favourable situations trees of this size may be safely considered sound and convertible into good marketable timber. There are in places many individual trees the measurements of which are far in excess of those just mentioned. One on the Ferguson River measures 22ft. in circumference 5ft. from the ground, and 80ft. from the ground to the first branch. It is a fine, straight, handsome tree, and should turn out at least 20 loads of good sawn timber. In good situations a tree attains a diameter of about 2ft., or reaches the stage when it may be considered fit for the saw mill, when about 40 or 50 years of age.

The Conservator has observed that jarrah trees seem confined to the South-Western Division of Western Australia. This Division lies along the West coast between 31° and 35° South latitude and 115° and 119° East longitude, a stretch of country which extends nearly 360 miles North and South and 50 to 100 miles East and West, and comprises all that country on which the heaviest rains fall, averaging annually 40in. in the South and 35in. in the North. An average of 10 years shows the average annual rainfall of this Division to be 38in.

The tree is not found much beyond the influence of the sea, and yet it is not at all partial to the direct effect of sea breezes. Perhaps the best jarrah forests are found 20 to 30 miles inland. It has not yet been ascertained whether this is simply due to the tree being found only in the heavy rainfall portion of the Division, nor whether the growth would be as good further inland if there were the same rainfall there. Its principal habitat is along the tablelands and slopes of the Darling Range of hills, which run through nearly the whole of the South-Western Division.

The late Baron Sir Ferdinand von Mueller, K.C.M.G., the world-famed Australian botanist, said—"Jarrah is famed for its indestructible wood, which is neither attacked by the borings of the Cheluria, Teredo, nor Termite." Its resistance to white ants is remarkable. Houses of it are almost indestructible when thoroughly seasoned, and have been known to exist in perfect preservation for nearly 100 years. It gets extremely hard with age, and becomes almost unworkable: it is impossible to drive in even strong nails into it, and when struck it rings like a bell. Many specimens are shown with surprising records of durability in the ground, and in both salt and fresh water. When freshly cut the weight of the wood is a little over 70lbs. per cubic foot, but it lessens to 60lbs. when thoroughly seasoned. It is red in colour and comparatively easily worked, and polishes splendidly.

The Royal Mint, Perth.

Some of the purposes for which it is used are—wood-blocking, piles, jetties, bridges, boat-building, posts, furniture, and railway sleepers. It makes excellent charcoal. Its peculiar adaptability to all kinds of out-door constructions is so well known that it is considered the staple wood of Western Australia. Its remarkable suitability for piles or any works requiring immersion in salt or fresh water is worth recording. In the office of the Woods and Forest Department there are specimens which have been obtained from piles and girders 60 years old. They were used in local harbours and bridges. When obtained as specimens the timber was perfectly sound and free from any sign of decay; if anything it seemed to be harder, more solid and more durable than freshly-cut timber; at all events, it seemed capable of standing tear and wear for 100 years longer. From its immersion in water it appears darker in colour than freshly cut timber, but no decay whatever is apparent. Pieces have been made into cups, card-cases, and other articles, and the polish they have taken equals if it does not surpass the finest old mahogany.* There are also instances of railway sleepers which were laid down 18 years ago, and seem still as sound as ever; and the records of fence posts having lasted long periods in the ground are almost without number.

Karri.

This is the giant tree of Western Australia, if not of the whole Australian Continent. It is not so well known as jarrah owing to the limited field of its growth and the—at present—comparative inaccessibility of its haunts.

The late Baron von Mueller gave the tree its botanical name because of the paleness of the leaves on their lower side compared with eucalyptus generally; the popular is the aboriginal name. In its youth it can hardly be beaten as an ornamental tree, being regular in its growth, straight and umbrageous, its leaves changing in a few years from an oval to those long broad shapes which mark its more mature condition. In this respect, and also in general appearance, it resembles much the sugar gum tree of South Australia (*E. corynocalyx*).

There is no doubt that karri is the finest and most graceful tree in the Australian forests. When matured and of large dimensions it is supremely grand, and in this respect at least it puts jarrah far into the shade. It is almost always straight in growth, and towers skywards for great heights without having even the semblance of a branch. A clump is like a mass of upright candles. The tree grows very rapidly and soon attains great height and dimensions. A forest of marketable trees can be produced in 30 to 40 years.

The bark is smooth and yellow-white in colour, but not persistent like jarrah. It peels off in flakes each year and has always a clean bright look. In consequence of this it is frequently

* Some splendid samples of carving in Jarrah—the work of Mr. Wm. Howitt, of Perth—are to be seen in the Western Australian court, notably a handsome Baptismal Font.

called white gum. The height is almost phenomenal. An average tree may be put down at 200ft. high, 4ft. in diameter 3ft. to 4ft. from the ground, and about 120ft. to 150ft. to the first branch. Trees of this size are generally sound in every respeet and may be expected to yield timber free from dry rot, gum veins, etc., to which large trees are usually subject. But mueh larger specimens are now and then found. On the Warren River it is not unusual to find trees 300ft. high, 20ft. to 30ft. in circumferenee at the base, and measuring more than 180ft. to the first braneh.

The geographical eonfines of the tree are 115° and 118° East longitude, and 34° and 35° South latitude. Those confines eomprise the more humid portions of the temperate region, where the annual rainfall is 35 to 40 inehes. It is a coast region and very distinct in its general physical features from anything else in Western Australia. The tree seems a component part of its surroundings. Immense forests of trees of straight and wonderful size spring out of a rich, deep, spongy soil, and yet the eountry is sufficiently undulating to make it hilly in parts, although not difficult of traversing by road or tram. The tree is sometimes found near the coast, but there it is seraggy, stag-horned, and branchy, and therefore not suitable for the sawmill, nor readily eonvertible to timber. Still it is essentially a coast tree, though shy of actual contact with saline particles, or of strong direct breezes. In this also it somewhat resembles jarrah, if not the eucalyptus family generally.

South of the Blackwood River the karri eountry consists of knolls and belts of red ehoeolate or partial ironstone-humus soils. Around them are low-lying plaees, valleys or swamps, consisting usually of deep vegetable *debris* soils covered with the usual *tea-tree, banksias, and low eucalypt scrubs, and with a low, inferior, scrubby kind of jarrah, which gradually intermixes with and merges into karri. Jarrah is usually subservient to karri, and therefore inferior in every physical feature tending to natural competition as a timber tree. Between the Blackwood River and Cape Hamelin, the country is of an entirely different nature, being of a limestone formation, with limestone on the surfaee and the soil sandy and ealeareous. This is a very remarkable phytological fact. The best karri forests are at elevations of 300ft. to 600ft. above the sea. The wood is red and very like jarrah wood, indeed it takes a good judge to distinguish the one from the other. Karri wood is hard, heavy, elastic and tough, but does not dress nor can it be wrought so easily as jarrah wood. For underground or water constructions it is inferior to some other woods, still posts and slabs are known to have been in the ground for 40 years with only an ordinary amount of decay. From tests whieh have been made in regard to

* So named because the first settlers in New South Wales (the parent colony) used the leaves as tea leaves. Baron von Mueller says in his report that "concomitant with tree culture the formation of tea plantations could proceed in all the South Western forest valleys, as the Chinese (or rather Assam) tea bush would prove quite hardy, aud iu the humid districts particularly prolific also. Tea is indigenous to Assam, and the resemblauce in appearance of the Australian tea-tree to the Assam tea-bush has been remarked, iu both the wood and the leaf."

its tensile crushing and breaking strength, karri is a wood of very high order indeed. It must therefore be regarded as one of the woods best suited for superstructures. It is also unequalled for bridge planking, shafts, posts, felloes, and large planking of any sort, flooring, general wagon work and beams. In lateral strength it is very much stronger than jarrah, and for works required to bear considerable weights, such as bridges, floors, rafters, and beams of various kinds it is of great value. It is much used in the Western Australian railway sheds for constructing wagons of all sorts. It shrinks laterally, but not to any great degree longitudinally. Altogether it is a most valuable wood. For street-blocking it is equal to, if not better, than jarrah, because traffic does not render it so slippery for horses' feet. It is largely exported for London street-paving, and finds a ready sale in South Africa—chiefly for purposes connected with mining.

Tuart.

This tree is of great importance. Its botanical name refers to the remarkably peculiar swelling or overhanging appearance of the lid of the calyx tube. The popular is the aboriginal name.

This tree is a handsome eucalypt, always wonderfully bright and cheerful in appearance. It is very ornamental when young, and is planted as an ornamental tree in some of the Australian colonies. It is straight and well clothed, and has a beautiful bright green leaf, and is not unlike the karri tree. When it has developed out of the seedling and sapling stages the leaves get narrower and more elongated. It is sometimes 150ft. high, and more than 22ft. in circumference at the base. Sometimes it rises 80ft. without a branch, but generally it has heavy tops with boles about 40ft. from the ground. It does not usually form dense forests, but likes plenty of individual room. It seems a fairly quick grower, and by cultivation attains a fair size in 30 to 40 years. Its general appearance is very much that of the box tree in the Eastern Australian colonies. Its bark is of a greyish white colour and somewhat crinkled. Its habitat is the limestone belts round the coast between Perth and Busselton, a calcareons strip of country hardly ever more than three miles wide, but always quite close to the sea and sometimes running into the coast sandhills. It seems gregarious and does not intermingle with any other timber tree, except perhaps partly in places with a kind of stunted jarrah. It is, of course, intimately associated with the banksias and melaleucas. The soil of the limestone belt is a sandy loam of considerable fertility, with a retentive sub-soil. The tree thrives well on it. It is a coast tree and its wood is the strongest, heaviest, and toughest in Western Australia. It is extraordinarily hard and so interlaced in the grain that it is difficult to split. It seasons without much shrinkage or splitting, resists changes of weather, and has some wonderful records. Its timber is used for railway wagons, buffers, engine-bearers, kelsons, stand-posts, bridge supports, dock gate frames, wheelwrights' work generally, shafts, and most other works where great strength, solidity, and hardness

are requisite. It is of a yellow-whitish colour and so dense that it is difficult to work.

Sandalwood.

This is a peculiar tree in appearance, more like a large bush than a tree. It is of low depressed habit, branchy, and heavily topped. It is seldom more than 15in. in diameter and 12ft. to 18ft. high, with stems about 8ft. to 10ft. long; but there are specimens more than 18in. in diameter, with stems 12ft. long, and weighing 3cwt. to 6cwt. Trees have been cut which each produced timber weighing more than half a ton.

The tree is fairly distributed inland except in the South-West. It grows most freely in barren sandy soil, and is frequently intermixed with wandoo, York gum and morrell. It is not gregarious. The first wood from the tree was delivered in Perth (the metropolis) by farmers in the Eastern districts about 50 years ago, and was exchanged for goods. It was then shipped to Singapore and China. The trade continued with varying success till about 1882, when it virtually ceased owing to a decline in prices caused by the Chinese market being overstocked. Consequently merchants were encumbered with large quantities of stock. But now there is a revival, and all the old stocks along the Great Southern Railway are fast disappearing through the port of Albany, which seems destined to be the chief shipping place for the trade. There is also a considerable quantity being cut between Northam and Southern Cross and the goldfields, and exported from Fremantle.

To allow the young trees and the cut-over portions of the sandalwood country to come up and grow to maturity, the Government set apart lately a very large area on which sandalwood-cutting of any kind whatever is prohibited for two years. This enables the tree to be maintained. The prohibited area includes all that portion of Western Australia from which sandalwood has been obtained for more than forty years. Young trees are now growing abundantly, and the renovation of the forest by natural reproduction is assured. Should it be found at the end of two years that the conserved trees are not sufficiently grown for use, the area will be prohibited for two years more, and so on until wood for the market can be cut from the new trees. In carrying out the reservation scheme care has of course been taken to leave a sufficient area open for cutting, in order that there may be no complaint about the curtailment of the operations of the sandalwood-cutters and the injury of the industry. The principal areas available for cutting are along the railway lines North of Southern Cross, where there are large quantities of matured trees waiting for the axe. They are within easy distance of railway communication and thoroughly accessible.

Provision is also made for restricting sandalwood cutting, so that even young and immature trees on ordinary Crown Lands outside of the prohibited area are in a sense protected.

BRIEF DESCRIPTION OF THE PRINCIPAL SECONDARY FOREST TREES OF THE COLONY.

A brief reference to the principal species of what may be classed as trees of secondary importance is necessary, as some possess woods of high class. Where popular names are unknown, botanical names are used.

Wattle.

The word "Wattle" is rather ambiguous. In Australia it is generally applied to any species of the Acacia family. In this case, however, its application refers only to *A. saligna*, from which the bark containing Mimosa tannin is obtained. In Mueller's "Select Extra Tropical Plants" it is called *A. leiophylla* because of the smoothness of the leaves. It is a small tree, rarely more than 30ft. high and 1ft. in diameter. But it spreads very widely and has timber of considerable size and good growth. Consequently each tree bears a fair quantity of bark.

It is somewhat handsome, and as it is umbrageous and fairly long lived, it is suitable for avenue and shade. The South-Western Division is its habitat. It appears to frequent deep rich places, where there is a fair amount of moisture—but not stagnant moisture—and grows in abundance without cultivation near Busselton. The country there seems to be peculiarly adapted to its growth. A valuable feature which commends it for culture is that it sends out suckers from the old stump after the parent tree has been cut down. The bark contains some 30 per cent. of tannic acid. The tree seeds prolifically, and if sown for culture the seed should be soaked in boiling water and otherwise softened before being sown. It germinates freely and is easily cultivated.

Raspberry Jam.

This is another well-known acacia. It is a small tree about 30ft. high with stems to 1ft. in diameter and boles 10ft. to 12ft. high. It is of a handsome rounded shape when allowed to spread out its branches, and the leaves are bright green and picturesque. The popular name is derived from the peculiar scent of the wood, which is wonderfully like that of raspberries. An oil of the same flavour is obtained from the wood by distillation. The wood is very dense and largely used for fences and survey posts. It seems to last for ever in the ground and to be impervious to white ants. It is a beautiful wood, dark in the middle, with a white margin on either side; and it is very heavy, and makes an excellent timber for cabinet and ornamental work of all kinds. Pipes and walking-sticks are sometimes made of it.

Badjong.

This tree is popularly known as Wattle Gum. It is found along the flats and river banks in the humid districts of the South-West, and often growing with raspberry jam in the Eastern districts. Its popular name refers to its peculiarity of exuding large quantities of gum each year, a peculiarity which makes it a valuable tree.

It is more than 40ft. high in favourable places, and its diameter ranges to nearly 15in. Its timber might be advantageously used for ordinary barrel staves and various kinds of soft wood turnery.

Peppermint.

This is a well known tree and sometimes called Willow Myrtle. It abounds along the sand banks and river estuaries of the West coast. It is a coast tree, and seldom found further inland than 15 or 20 miles, and then only in the flats and sand drifts or washes of the more sheltered portions of the rivers. It is to be seen 40 miles from the coast, but only in specially favoured spots. It is very handsome and, with its dense drooping foliage, makes a fine tree for shelter, shade, and ornament. The flower is white and covers the tree like a spray of snow. It is well suited for street planting. There are fine avenues of it in the streets of Albany, Bunbury, and Busselton; and it is also to be seen in Perth. The wood is hard and durable, and makes excellent firewood. When crushed the leaves emit a strong perfume like peppermint, hence the name; and the oil distilled from them possesses strong antiseptic properties. It is often more than 50ft. high and is 2ft. to 3ft. in diameter at the base.

Banksia.

The Banksia trees and shrubs are an interesting feature in the flora of Western Australia, but they are more ornamental than useful. The river banksia is a fair-sized tree, and always found growing on rich alluvial flats or the banks of rivers. It is rather handsome and well grown, and has a very striking appearance when in flower, with its yellow-red erect cones and light green leaves. The wood is soft and light coloured, and used for making furniture and house fittings. It should make good staves. It is very good for making tables likely to be subject to rough usage. It seems to become hard and durable with age. All the banksias are largely used for firewood.

Sheoak.

There are several species of Casuarinas, those in the list being only the most prominent. Casuarina Fraseriana is chiefly found in the South-Western Division. It yields a good timber for furniture, and is much used and well adapted for shingles, being durable and easy to split. It is fairly light in weight and beautifully grained. It is also very ornamental, and suitable for planting in parks and pleasure grounds. It is very gregarious, and only found in clumps here and there in jarrah and karri forests. It is also found on dry knolls, poor soils, and rich bottom flats, and is always of greater size and beauty on the flats.

Red Gum.

Next to jarrah there is no tree so widely distributed as red gum. It is found intermixed with jarrah, wandoo, York gum and karri. It is the most numerous species in some places, but it cannot exactly be called gregarious. It is the only tree of any consequence between the Moore River and Busselton. It is common

in the forests of the South-Western Division, which seems to be its only habitat. Although sometimes found growing luxuriantly on high ironstone ranges, it seems to delight most in deep red soils of flats and valleys, and in some places it is the principal, if not the only tree. It is seen to advantage about Perth and some municipalities and townships, and along the railway line to Bunbury. It grows as well in deep, sandy, porous soils as in those that are clayey and retentive. The botanical name refers to the beautiful appearance of the leaves; the popular has no special reference, unless to the gum which exudes from the tree, which is of a red colour and gives the tree and the surrounding vegetation a reddish appearance. In karri country, where the soil is of a deep rich, loamy character, the tree is less subject to gum veins than elsewhere, and consequently the timber is more marketable.

The gum is a *kino* of some considerable value for its medicinal properties. It exudes from the tree in summer in a thick, treacley condition—generally from the trunk, but often from the main limbs also. It is worth about £25 to £30 per ton, and is easily collected, whether liquid or dried. It is locally used for tanning. The hard, rough, and irregularly furrowed or broken appearance of the bark adds considerably to the rugged aspect of the tree. It is widely distributed, but its timber is classed as only of second-rate quality, because of gum-veins which intersect it in every direction. Otherwise the wood is excellent. It is locally used in short lengths for axe and other handles, spokes, naves, rails, harrows, shafts and other farming implements. Although sometimes subject to attacks of white ants, it is not apt to be destroyed by them. It has been frequently used for outdoor constructions by settlers, especially in the early days of settlement, and there are some valuable specimens in the Museum of the Department of Woods and Forests. But the excellence of the tree lies in its uniform umbrageous and spreading character, which makes it the best shade gum tree.

When standing alone and allowed to spread and develop its branches it is very handsome, picturesque and shady; and it is invaluable in summer in pastoral country. Its flowers are large, white, prolific, and full of honey. Consequently, agriculturists plant it round their holdings. It is fast growing, highly suited for ornamental planting, and makes splendid firewood.

Wandoo.

This tree is sometimes called White Gum. Its botanical name refers to the curvature of the lid of the seed vessel, but the curvature is not sufficiently pronounced to justify the reference. Wandoo is the aboriginal name. The habitat of the tree is very extensive. It may be said to be the principal forest tree on the Eastern slope of the Darling Range. It is also found at intervals Northwards to Geraldton and Eastwards to the goldfields. It has a sort of yellow-white, blotchy look, not clear-white like karri, but more or less speckled, though smooth. It is well-balanced and sturdy looking, and is always a clean, bright object in the landscape.

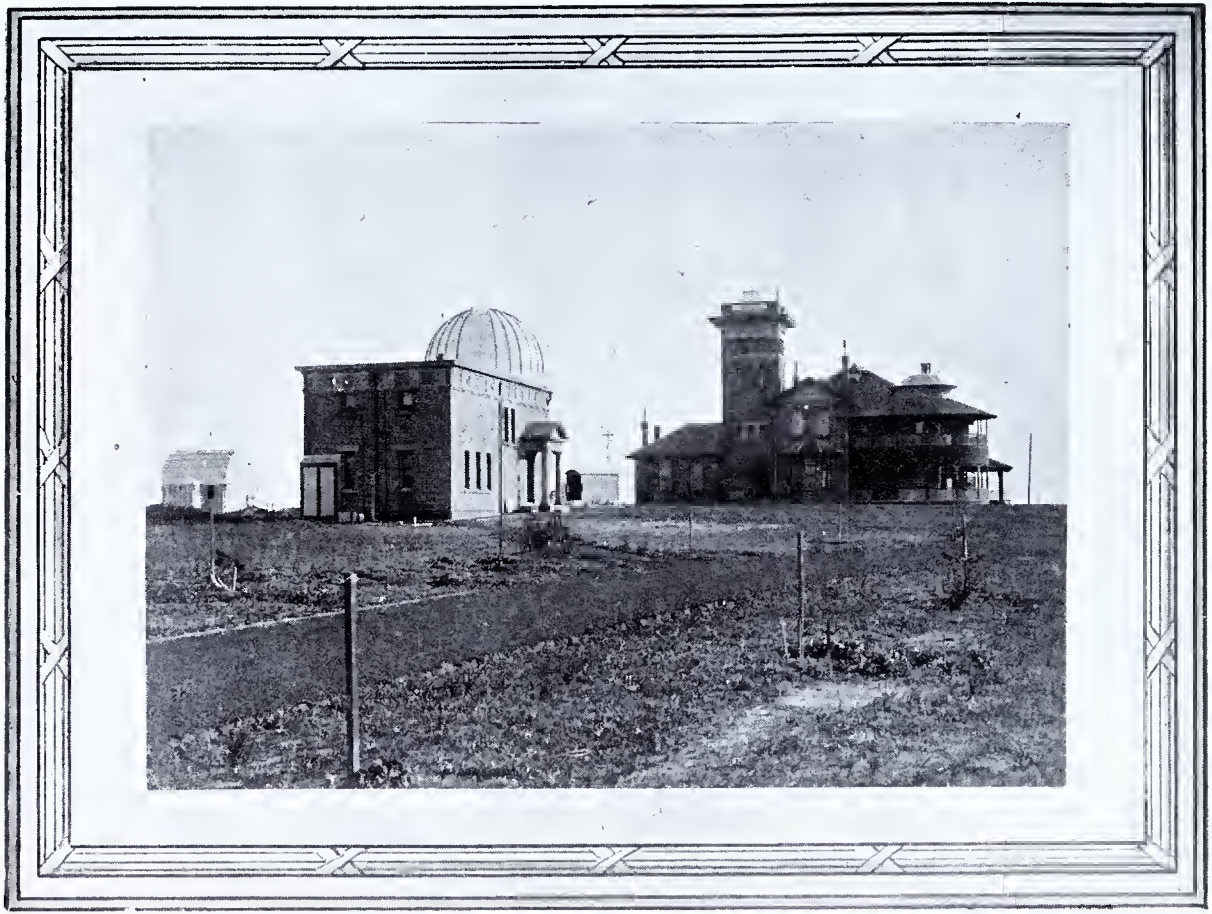
It is not very large. Specimens 60ft. to 80ft. high, with diameters of 1ft. to 2½ft., are fairly representative of the species, although some are a little more than 100ft. high and 3ft. in diameter at the base.

The country on which wandoo is found growing abundantly and most luxuriantly is cold, hard, unpromising decomposed granite —a flat, stagnant soil, sandy on top and invariably resting on pipe-clay. It is very boggy country in winter and hard in summer, yet the tree seems to thrive well. The country is fairly well grassed as a rule, but in many cases it is infested with one or other of the poison weeds. In some cases the tree intermixes slightly with jarrah and blackboys, and then the soil improves and has more loamy and friable particles.

Wandoo tracts form fine open forest country, but for the most part they are destitute of natural water. Good, plentiful water can be obtained by sinking to comparatively shallow depths. The timber is rather superior. It is hard, very dense, somewhat dull or dark yellow in colour, durable, and remarkable for its lateral and compressive strength. It is frequently used for naves, cart and buggy shafts, spokes, felloes, and other rural purposes, and for railway truck construction, receiving-buffers, and other works requiring resistant strength. It is of great importance and will eventually vie with, if not surpass tuart. It is highly suitable for mining. It weighs 70lb per cubic foot, even after it has been seasoned for a considerable time. It is one of the principal trees on the goldfields, and there are several saw mills which cut it for general mining purposes. Were it not for wandoo the mines would be badly supplied with convenient stock. It was frequently used for general outside work in the early days of the Colony. Altogether it is a remarkable timber and very valuable.

York Gum.

The botanic name of this tree refers to the oblique vein of the leaves; the popular is owing to the tree being plentiful about the town of York. It is more or less scattered all over wandoo country. The bark is rough, dark-coloured, and persistent, and easily distinguishable from wandoo bark by its dark, rugged appearance. In other respects the two trees resemble each other in growth, habit, and general surroundings. The York gum rarely exceeds 100ft. in height, and 3ft. in diameter at the base. Generally it is about 70ft. to 80ft. high, and 18in. in diameter. It appears to grow in any soil, but prefers the richer and loamy deposits along depressions and watercourses. The wood is exceedingly dry, hard, heavy, and tough, and is considered one of the best for constructing naves, hubs, felloes, and general wheelwright's work. It is in great request for such articles, and can hardly be surpassed. A large number are daily manufactured at Newcastle, and sent to various parts of the country. Inquiries for it are now being made by wheelwrights in Melbourne, the largest city in Australia, and there will soon be a market for it there. It is said to be the very best timber in Australia for those purposes. In the



The Observatory, Perth.

office of the Woods and Forest Department there is a portion of a felloe which had been more than 40 years in use in an old wheel, and the wood appears to be as sound as ever. Its usefulness might be extended to works where toughness and general strength are required.

Mallee.

There is not much to say about this tree. It is found in different parts of the inland scrubs of Australia, but only about from 20ft. to 30ft. high, and of proportionate diameter. It is referred to here only because, according to Baron von Mueller, a valuable oil is obtained from its limbs. It occurs in small clumps here and there in wandoo and York gum country, but further East and North there are considerable belts of the tree which will, no doubt, in time be used to produce the oil.

Crimson Flowering Gum.

It is not because of its value for timber that this tree is mentioned, but because it is the most gorgeous and remarkable species of flowering tree in Western Australia. It is small and very handsome, branchy and umbrageous. Its foliage is dark-shining green, and the leaves stand out flatter and less perpendicularly than is usual with the Eucalyptus family. It grows to a height of 40ft. and more, with stems averaging about 1ft. in diameter. The bark is rough and somewhat like the red gum, and the wood is of a dark blood hue. Baron von Mueller in his description of the tree says:—"There are other large flowered Eucalypti peculiar to West Australia, for instance, 'E. Preissiana,' 'E. tetraptrea,' 'E. ptychocarpa,' 'E. erythrocorys,' and 'E. Youngiana,' the seeds of all which could be made an article of commerce."

Flooded Gum of the Interior.

This is perhaps one of the most widely distributed Eucalypti in Australia, being indigenous to all the colonies, but it may be under different physical circumstances in each. Perhaps no tree has supplied more material for railways, bridges, jetties, piles, and telegraph posts in Victoria and South Australia. It is the principal tree in Australia, and it is only due to defective land carriage that it has not been much used in public works in New South Wales, the parent and most populous colony. It is the true red gum of Australia, and no tree is better known to explorers. Nearly all landmarks, camp locations, and "signs," left by those intrepid adventurers have been recorded upon trees of this species.

The bark is smooth, white, and annually deciduous. The wood is red, weighs about 60lbs. per cubic foot, is admirably adapted for constructive work of all kinds, and resists white ants and teredo as well as most woods. It is not met with farther south than the river Murchison.

Yate Gum.

This tree was first discovered at Cape Leeuwin, and named by Labillardière.* The botanical name refers to the long horn-like appearance of the operculum or lid of the calyx. The popular is the aboriginal name, and in some places the tree is also called white ironbark. Although not very abundant, it occupies a considerable place among the valuable trees of Western Australia. It is found all over the Southern Division, but only in small patches. It seems to prefer low-lying places where the soil is deep and fairly moist. There are some good specimens met with about Lake Muir, and in the country lying between that lake and Forest Hill. It is often found in the hollows of the wandoo country.

The bark is persistent, dark, rough, and rugged at bottom, but deciduous at top. The leaves on falling leave the branches white, like karri. The tree is not very large, the extreme height being about 80ft., the diameter 3ft. to 4ft., and the stem 40ft. from the ground to the first branch. It is easily raised from seed, and is hardy and a fast grower, adapting itself readily to situation, with an annual rainfall of 15 to 20 inches. The timber is excellent, and much used for shafts, spokes, naves, felloes, boat ribs, and agricultural implements generally.

Morrell Gum.

This tree is 50ft. to 60ft. high and 12in. to 18in. in diameter. It prefers loamy soil, but is partial to any good strong soil with some body. Baron von Mueller says it is probably closely allied to *E. oleosa*. Its habitat is from the Upper Swan River Eastwards beyond Northam towards Newcastle. The bark is rough and something like yate bark. The timber, which is of a dark reddish colour, is hard, heavy, and very strong in every way, but especially in lateral tension; it is highly recommended for such works as general wheel manufacture, shafts, blocks, tool-handles, mallets, and other implements which require to be tough, strong, and durable. Morrell is the aboriginal name of the tree; the botanical name refers to the long horn-like lid of the calyx. The leaves are especially rich in oil, and therefore available for its extraction.

Red-Flowering Mallee.

This is virtually only a Mallee tree, and is only mentioned because of the beauty of its flowers, which are large, spreading, red-coloured, and wonderfully handsome. It is only found in a dwarfed form in the interior on the South Australian border. The calyx is unusually large and angular, hence the botanical name.

Blackbutt.

This tree has its habitat only in the gullies and richer parts of the South-Western Division. It grows on the rivers Canning, Serpentine, Harvey, Collie, Brunswick and Blackwood; in fact, it

* The distinguished French naturalist who accompanied the expedition sent by the French Government to search for the no less distinguished but ill-fated French navigator and discoverer, La Perouse.

may be safely said that there are specimens of blackbutt on the Western slopes of the Darling Range wherever there are good, deep, moist soils. It is never found in large groups, but always in clumps, or singly, according to the peculiarity of the soil. It is especially abundant at Balbarup, Dingup, and along the river Blackwood, especially from Bridgetown downwards. In the Blackwood Gorge it predominates above all other trees, and grows to a large size. Large specimens may be seen in the Collie Division. The timber is sound and of good quality, and is gradually increasing in demand in the local market. It might be very advantageously used for street blocking. It is light in colour, hard, tough, and durable, and is locally used for such purposes as constructing wheels, shafts, and farming implements. It is, certainly, a good timber, and is gradually taking a place in the local market. It seems to last well underground. There is an instance at Dingup where slabs, which were used twenty years ago in the construction of a cattle yard, are now quite sound, with the exception of a little decay between wind and water. Fence posts are shown at Deeside, 190 miles South of Perth, which had been 50 years in the ground. The wood is very difficult to split or burn. The bark is persistent, hard, deeply dented, and dark grey in colour. The tree always indicates rich soil. It is often 140ft. high and 4ft. to 7ft. in diameter.

Blue Gum.

This tree is found in small clumps about Karridale, Busselton, Mt. Barker, on the rivers Tone and Gordon, in the creeks along the Eastern slopes of the Darling Range, and on the sandalwood tract between Bunbury and Williams River District. It is about 70ft. high and 1ft. to 3ft. in diameter, with a smooth, white, deciduous bark.

The botanical name refers to the large size of the seed vessel, and the popular is apparently due to the tree resembling the great Tasmanian blue gum tree *(E. globulus).*

Salmon Gum.

This tree is 40ft. to 70ft. high, and 12in. to 30in. in diameter. The grey and slightly-purplish smooth bark is of an oily lustre, and to it the popular name of the tree is due. It is patchy in its habitat, and often gregarious. In wandoo country it is occasionally met in clumps, chiefly on the ridges or rises; but its home is Eastward of the Darling Range, from the upper reaches of the river Swan to the dry inland districts of the goldfields; and it is found intermixed with morrell and gimlet gum trees. It is common East of Newcastle, Northam and York, and along the Yilgarn, Midland and Great Southern railways. It is of a fair size along the Midland railway, and the timber has been used with great success in constructing railway bridges and culverts. The tree prefers a good stiff loamy soil on top, with a clay sub-soil. It is hard, heavy and durable, and used in mining on the goldfields, and at Northam and Newcastle in wheelwright work.

Gimlet Gum.

This tree is intimately associated with the salmon gum tree, and the two together often form considerable areas of forest. The name is derived from the strongly fluted or longitudinally twisted character of the outer surface of the stem of the tree, which is very peculiar, and a unique feature. It prefers good, retentive soil, and its chief habitat is in the dry country East of the Darling Range. It is common in the forests East of the Meckering Agricultural Area, and also in the country lying along the Yilgarn railway, where it spreads out North and South. There are patches of the tree at Carnamah, on the Midland railway, and with the salmon gum tree it stretches beyond Coolgardie goldfields. The timber is of much the same class as salmon gum timber, and is in general use on the goldfields. It is highly suited for cabinet work.

Native Pines.

These trees grow here and there in various parts of Western Australia, chiefly in poor and sandy soils. The cypress pine is the most important and most widely distributed. The timber is of splendid grain and not readily, if at all, attacked by white ants. It is hard and light coloured, and has an agreeable scent and weighs about 40lb. per cubic foot. It is particularly well suited for house-building where white ants are numerous, as was found by the South Australian Government when constructing stations and other buildings along the Port Darling and Pine Creek railways. It is also suitable for furniture making, yokes, boat knees, walking sticks, door panels, wainscots, and picture frames.

Paper Barks.

There are several kinds of paper bark. They are always found in swamps and on river banks and the moist alluvial flats bordering rivers, and chiefly on the coast. The bark, with its many layers of paper-like consistency, is a marked peculiarity of the tree, and is well suited for packing fruit for export. The timber is hard, durable and cross-grained, lasts well underground and resists white ants. It is not much used in Western Australia, but is useful for ship-building, posts, short piles, and fencing.

Christmas Bush.

This tree is mentioned not because of the value of its timber, but because of the picturesqueness of its flower. It has a striking appearance in the forest at the end of the year, hence its popular name. It belongs to what is known as the *Loranthe*æ order. None of these are cultivable, all being genuine parasites. It is found among jarrah and banksias on the flats between the hills and the coast. The wood is white, soft and spongy, and of no commercial value. The flowers grow in pendulous clusters, covering the whole tree and giving it a gorgeous bright orange colour.*

* Note.—There are several other indigenous Eucalypts and Acacias, but they are not enumerated here as they are not of any particular economic importance.

The Public Hospital, Perth.

FOREST AREAS.

The physical features of the forest areas are all very much alike. The forests are virtually all situate in the South-Western division of the country. It is only there that the great commercial timber trees grow, although there are timber belts in much of the country outside that division which are in great demand in local markets. The demarcations of the areas on which the principal trees grow have been carefully calculated. They are as follows:—

	Acres.
Jarrah, chiefly (with Blackbutt and Red Gum) ...	8,000,000
Karri	1,200,000
Tuart	200,000
Wandoo	7,000,000
York Gum, Yate, Sandalwood, and Jam	4,000,000
Total area of the principal forest surface of Western Australia	20,400,000

These figures were published in 1896. Although many conditional purchase blocks have been since alienated, their acreage is very small, and does not appreciably affect the foregoing total.

ESTIMATED QUANTITIES AND VALUES OF THE MATURED MARKETABLE TIMBERS.

Although he believed it to be considerably under what actually exists, the following is the Conservator's estimate of the matured timber growing at present:—

	Loads.
Jarrah	40,000,000
Karri	15,000,000
Tuart	300,000
Wandoo, York Gum, Yate, Blackbutt	7,000,000
Estimated total loads of round matured timber now in the Forests of Western Australia ...	62,300,000

This matured timber is worth 60s. per load to the country, that sum being the average amount retained for wages, haulage, trainage, ship-loading, and cost price. The marketable timber is thus worth about £124,000,000 after deducting one-third for waste in sawing. This does not include red gum timber.

PROSPECTIVE VALUE OF THE FORESTS.

The forests have a bright future before them, and will become a lasting revenue-producing asset of the State. Nothing worth mentioning has yet been done to prevent the forest industry being a success—an encouraging fact to those who have instituted the present complete system of forestry in Western Australia.

The value of jarrah and karri forests is now being recognised; they are no longer looked on as a nuisance and a hindrance to settlement. Where, years ago, forest areas could be almost obtained for nothing, they are now eagerly sought after at fairly good prices. The individual who possesses a bit of good forest land may consider himself fortunate. A beginning has only been made as yet, but what has already been done gives an idea of the magnitude the industry will assume if fostered.

There are at present more than 2,000 men employed in the various saw mills. Including their wives and families, and all the other timber cutters in Western Australia, they number from 8,000 to 10,000 persons, more or less dependent on the present output. The capital represented by the various saw mills, railways, tramways, jetties, locomotive engines, trucks, wagons, live stock, and buildings, may be safely assumed as not far short of one million sterling. The total output of sawn stuff of all sorts from the mills last year was over 322,000 loads, representing a gross value of nearly £2,000,000. These are only a few of the most striking figures.

During the last two years the development of the industry has been most marked; and before the end of the present century the capital invested, the number of men employed, and the output of the timber, are morally certain to be four or five times those figures. The public finances ought to be benefited by the increased trade. The country, no doubt, benefits indirectly through the Customs in increased consumption of dutiable goods, still, the Forest Department should be able to show a fair revenue for the timber removed. At present only the individual cutters are reaping the benefit.

EXOTIC TIMBER TREE PLANTING.—STATE NURSERY.

Western Australia is capable of growing with success almost any tree it imports, and there is no reason why it should not. Much money is annually sent out of the country for soft woods. This imported timber is undoubtedly necessary, and therefore cannot be done without, the native woods being too hard and heavy for many purposes; but regard must be had to the possibility that in time the supplies available for import will become so impoverished as to be unable to supply our wants. Therefore efforts must be made for the country to supply them. To that end a State nursery has been established at Drakesbrook, on the South-Western railway.

The following list comprises some of the principal exotic trees of soft and hard wood, which yield the timbers imported, and which can be successfully grown in the country:—*Acer campestre, Acer negundo, Acer pseudo platanus, Acer macrophyllum, Acer platanoides, Acer nigrum or saccharinum, Acer rubrum, Araucaria excelsa, Araucaria cunninghamii, Abies Douglassi, Abies pectinata, Abies excelsa, Catalpa speciosa, Cedrela Australis, Cupressus Lawsoniana, Cupressus sempervirens, Cupressus torulosa, Carya alba, Carya tomentosa, Carya oliviformis, Carya glabra, Castanea sativa, Dammara Australis, Fraxinus Americana, Fraxinus excelsior, Grevillea robusta, Juglans nigra, Juglans regia, Larix Europea, Pinus strobus, Pinus ponderosa, Pinus insignis, Pinus halepensis, Pinus pinaster, Pinus Lambertiana, Pinus pinea, Pinus excelsa, Pinus Australis, Pinus radiata, Quercus pedunculata, Quercus sessiliflora, Quercus Suber, Salix alba, S. Purpurea, S. rubra, S. triandra, S. Forbyana, Ulmus campestris, Ulmus montana, Ulmus suberosa, Populus alba, Populus fastigiata, Populus Canadensis, Populus nigra, Populus canescens, Robinia Pseudo-Acacia, Sequoia gigantea, Sequoia sempervirens.*

THE PEARLING INDUSTRY.

(By Walter Kingsmill, M.L.A.)

The Pearling industry, as carried on in Western Australia, is one of which but little is known in the Southern and more thickly populated districts of the Colony, nor, indeed, in any part other than that in which the operations in connection with this pursuit are actually prosecuted.

Thus it comes to pass that the magnitude and importance of this industry barely receive the appreciation which should be their due.

The causes which tend to this result are not far to seek. In the first place the centres of activity of the industry are remote from the more settled portions of the Colony; and, secondly, most of the commercial transactions in connection therewith are carried on direct with London, the greatest and practically the only distributing market for the product, in many instances pearlshell won from Western Australian waters being shipped direct from the pearling vessels, without even being landed on Western Australian soil, on steamers bound to Singapore.

The species of oyster found in Western Australian waters whose shell supplies the beautiful and largely used commodity known as Mother-of-Pearl, are limited to two, of which the smaller, scientifically known as *Meleagrina radiata,* and to the trade as Sharks Bay shell, occurs on the more Southern portion of the shell-bearing coast of the Colony, its distribution being (roughly) from Sharks Bay to Nor'-West Cape, and the principal centre of operations being in and around Sharks Bay, where about 60 persons are employed in its collection.

The shell derived from this species is of comparatively small value, and realises upon the London market a price fluctuating between £20 and £80 per ton. Indeed, in the earlier days the oysters were obtained for the pearls alone, the shell being then regarded as a waste product. This is due to the fact that the nacreous portion of the shell is very thin, hence only the smaller articles for which mother-of-pearl is employed can be manufactured from it.

The pearls contained by this species, while as a rule fairly plentiful, are of small size and wanting in the brilliant and yet soft lustre which characterises those found in more Northerly waters. A large proportion of them are straw-coloured, and even of a golden yellow, a hue which is somewhat unfashionable in this gem, though specimens have not been wanting which have realised good prices in London. The greater portion of these shells, however, find a sale in the Singapore and Chinese markets.

As these shells are inclined to be gregarious, occurring thickly and in defined beds, the method of their collection is principally by dredging. Owing to the wholesale destruction of shell involved by this process, it has been found necessary to take the precaution of periodically closing certain portions of the waters worked for them, and leases (known as "Exclusive licenses") of specified and defined areas are obtainable for the purpose of cultivation.

Under these conditions it is probable that pearling may be profitably carried on for an indefinite time on this portion of the coast, while there seem to be fair prospects, from the experiments of Mr. Saville-Kent, that the larger and more valuable Nor'-West shell may be acclimatised here, and may take the place of the inferior species now being obtained.

From Nor'-West Cape Northwards, throughout the vast extent of the remaining portion of the West Australian coast, the Sharks Bay species of pearl oyster is wanting, its place being taken by the much larger and more valuable variety (*meleagrina margaritifera*), known as Nor'-West shell, which furnishes by far the greater proportion of the mother-of-pearl sent from this Colony to England.

It will be seen by a glance at the map of West Australia that the habitat of this species embraces an enormous length of coast line, and when it is taken into consideration that the shell is known to occur from practically low water mark to the greatest depth attainable by the present form of diving apparatus (such limit being sometimes 15 and even 20 miles from shore), we may realise what a vast extent of sea bottom is workable for shell, and what a small impression on the vast supplies of this article provided by Nature can be made by the efforts of those few people engaged in this industry. Considerable variations in the character of the shell raised at different points along the coast are noticeable, due, no doubt, to changes in the nature of the bottom, the quality of food obtainable, etc. Thus, for instance, it is found that from a rocky or coral bottom shell is obtained which is more prolific in pearls, but which is also more liable to be worm-eaten, and hence is of less value; again, in the neighbourhood of the Monte Bello Islands, situated off the mouth of the Ashburton River, shell is found which, from some cause, is of abnormal size and thickness, probably owing to the greater ease with which the oyster in this locality obtains its food supplies. By that law of compensation, however, which appears to run throughout the great scheme of Nature, these shells are proportionately rare and sparsely distributed.

Concerning the life history of the pearl oyster but little is definitely known, owing, no doubt, to the difficulties attending observation and the lack of systematic experiment in connection therewith. Their method of reproduction is known, in common with the other species of the oyster family, to be by the emission of what is known as "spat." These embryonic oysters are produced by the parent shell-fish in such immense numbers as would soon convert the ocean into a mass of pearl shell were it not for the fact

Pearling Luggers, Roebuck Bay.

that in their early stages they fall easy victims to a horde of natural enemies.

The percentage of survivals amongst the embryo pearl oysters must be infinitesimal, nor, indeed, when they have reached an age and size which protect them from the attacks of the majority of their persecutors are their troubles entirely at an end.

Amongst the enemies of the oyster in its more mature stages must be reckoned several species of starfish, which attach themselves to the shell and wait patiently till it has at last perforce to open, when the fish inside provides them with their long expected meal. Again, marine borers play havoc with them, and it is probably by the efforts of the oyster to defend itself against the attacks of these insects, by the deposition of an extra thickness of the hard nacreous substance forming the interior lining of the shell, that those protuberances, known technically as "blisters," are in some cases formed; these formations are occasionally of great beauty and of considerable value for mounting as pendants, brooches, etc. The ravages of borers greatly detract from the commercial value of the shell, and are more prevalent in the older specimens. Yet another and more formidable antagonist is met with in the species of turtle known as the loggerhead, against whose powerful jaws the shell of the oyster, thick and strong though it be, often offers but an inefficient protection. It can therefore be readily understood how small a proportion of the spat reach maturity. The age at which a pearl-oyster becomes marketable is variously assessed by pearlers of experience at from three to four years, and at that age they are, from a commercial point of view, most esteemed.

With regard to the formation of that beautiful gem, the pearl, the generally accepted theory seems to be that it is formed by the action of the oyster in coating any foreign substance which may happen to intrude itself into its pearly domicile with the nacre which they have the power of secreting at will.

Pearls occur both as detached fragments within the shell, and also as attached thereto, and covered over by the blisters above referred to.

They are found of nearly all shapes, but when symmetrically formed they are, of course, of the greatest value, especially if perfectly spherical, pear shaped or ovoid, and in these cases (the lustre, colour, and weight being satisfactory) form very high-priced gems.

The pearly matter occurring in irregularly shaped masses is known as "baroque," and bears a value principally speculative, on account of at times containing, within a most unpromising exterior, more or less perfect pearls. The same remarks apply to the blister formations.

The colour of the pearl is one of the principal factors in the determination of its value, and varies greatly from pure white through different shades of colour to black. These latter are very valuable when of good size and lustre. Pink pearls are also found,

and bring large prices as much on account of their rarity as of their extreme beauty. The lustre of this gem affords another criterion of its worth, and varies extremely. In connection with this point, the extreme skill of many of the persons engaged, both in obtaining and in buying pearls, in treating pearls and baroque, which at the first glance would appear almost worthless, is worthy of note.

By the delicate operation of removing one or more of the almost microscopic concentric layers of nacre of which the pearl is composed, from the most unpromising material a high priced gem is often evolved.

Taking note of the above facts it is easily seen that pearl buying forms an occupation calling for the exercise of a very large amount of tediously acquired expert knowledge, and that purchases are often highly speculative, and as a matter of fact those engaged therein would often seem, to the uninitiated, to be guided in their selections by a sort of instinct developed by long practice. They rarely, however, make mistakes, and generally realise large profits on their transactions. Returning to the more particular aspect of the question as affecting the West Australian industry, it is found that the bulk of the smaller pearls discovered in these waters are acquired by local buyers, but it is customary in the case of the larger and more perfect gems for the lucky finders to despatch their treasure trove to London for more direct sale. During the last session of the West Australian Legislature an Act embodying the principle of the well-known South African Illicit Diamond-buying Act, as applied to pearls, has become law, whereby severe penalties are imposed on persons trafficking in pearls without the acquisition of the necessary license.

This has been found necessary to guard proprietors against, and to more easily trace, the peculations which frequently take place by the agency of coloured employees, who often display a large amount of ingenuity in securing, and subsequently concealing the pearls of their employers.

As illustrating the comparative difficulty with which information concerning the finding of pearls reaches the public, it is worthy of note that if a piece of gold, say, of the value of £1,000, is found, the fact is noised abroad through and outside of the Colony by medium of the Press; whereas, though many discoveries of equal value in the form of pearls are undoubtedly made, it is but rarely that anyone, unless intimately in touch with the industry, hears anything about it.

With regard to the early history of the Nor'-West pearling industry, it must be confessed that reliable information on this head is meagre and hard to obtain.

Operations have been conducted in the district for about the last 30 years. It would be difficult and invidious at this distance of time to definitely state to whom the origination of the industry is due, but amongst those connected therewith in its infancy the

names of the late Mr. Shakespeare Hall, and of the Messrs. Sholl Bros., of Cossack, and also of Messrs. Mackenzie Grant and Harper, of the DeGrey station, stand forth prominently.

In the early days the search for pearl-shell was usually conducted as an adjunct to pastoral pursuits, and the services of the aboriginal natives of the country were called into requisition as divers or beach-combers, when not required in their ordinary station work.

These natives were the servants of their employers under annual agreement, concluded by the parties thereto under the supervision of officials appointed for that purpose, whereby their services were given in return for good clothing and medical attendance, and their pearling labours were conducted under the eye of an inspector, appointed and provided with a schooner by the Government, whose duty it was to see that the terms of the mutual agreement were carried out.

Their work in connection with pearling consisted either in diving from boats, and so searching the bottom for shell, or in beach-combing, which consists in traversing those portions of the coast laid bare, or nearly so, by the great ebb and flow of the Nor'-West tides.

In this manner the pastoralists of the pioneer days of the Nor'-West were enabled to add very materially to their profits, and gradually a class of men appeared on the scene who found that they were handsomely repaid by turning their attention solely to pearling.

Naturally, although the Nor'-West natives may be counted as extremely skilful swimmers and divers, by the aid of naked diving only the shallower portions of the coast could be exploited, and with the introduction of the diving dress some years back the pearling industry received its first great impetus and began to assume more important proportions, and to attract the attention of outside capital. Amongst many others Messrs. Streeter & Co., the well-known jewellers and gem dealers, of London, found it worth their while to equip a pearling fleet and to start operations at Broome, a town to-day of some 450 inhabitants, situated at Roebuck Bay, on the Nor'-West coast, and which has supplanted Cossack as the centre of the industry.

Gradually the more primitive native divers gave way before those equipped with dresses, and now but few natives are employed in pearling, and those principally in beach-combing.

To-day the vessels engaged in pearling sailing out of Broome comprise 17 schooners, of a tonnage varying from 60 to 180 tons each, and 135 luggers of from 10 to 15 tons each, in addition to a smaller number still making Cossack their headquarters.

The actual diving is carried on from the luggers, several of which accompany each schooner and repair to her with their daily take of shell.

Aboard the schooner the owner, or his representative, supervises the opening of the shell, the extraction of the pearls, if any, and the subsequent cleaning, packing, and despatch of the shell to its market in London.

The bulk of the shell reaches its destination *viâ* Singapore, travelling thither by the four fine steamers belonging to the West Australian Shipping Company and Ocean Steamship Company, Limited, and trading between that port and Fremantle.

The pearling fleet above mentioned as operating from Broome employs between 900 and 1,000 hands, consisting principally of Malays, Manillamen, and Japanese, with whites in the responsible positions. The wages paid to the coloured employees are as follows:—For divers, in which capacity the Japanese are found to excel, £2 per month and a "lay" of £20 per ton of shell raised; this brings the average wages up to about £3 per week, which, to the frugal Oriental mind, approaches affluence.

The robust constitution of the sturdy little Japs is found to better withstand the strain of diving at the deeper levels than is the case with most other nationalities.

For each diver a "tender" is required, whose duty it is to see to his requirements while below, attend to the life line and the signals which are transmitted thereon by a specified system of pulls, work the air pump which supplies the diver with his life-giving supply of air, and generally to act as his *fidus Achates;* the wages of this functionary are generally £4 per month.

The crew, principally Malays, receive £2 10s. per month each, and their work is, like that of ordinary seafaring men, multifarious.

The Malays employed on the pearling grounds are recruited principally from Kopang and Sourabaya, and are engaged for a term under an agreement ratified by the Netherlands Government, providing for their safe return to their port of shipment when their term of service has expired.

The Japanese and Manillamen are generally engaged each on their own individual agreement.

The behaviour of these men is, as a rule, satisfactory, though there have, unfortunately, been cases where dissensions between masters and men have been attended with tragic consequences.

One such case occurred within the last few months, when, in a mutiny on board of the brigantine Ethel, the owner (Captain Reddell), his son, and first mate lost their lives at the hands of the coloured crew; happily, however, the perpetrators of the crime have been captured and will probably pay the penalty of their misconduct.

In justice to these hard-working people it must be stated that such instances are isolated, only another such occurrence being chargeable against them throughout the history of pearling on this coast. The season for obtaining pearl-shell lasts from April till December, the interval between being, as a rule, spent by the boats

Messrs. Streeter & Co.'s Pearling Fleet—Broome, 'Roebuck Bay.

in some sheltered spot on the coast, where the vessels are laid up, overhauled, and the necessary repairs made.

This respite from active work is also rendered advisable by the fact that from December to April the weather in this locality is extremely unsettled, cyclones (locally known as "willy-willies") often occurring at this time of year. These winds much resemble the typhoon of the China Seas in duration and force, and small vessels would have but little chance of weathering them.

Some details of the cost, etc., of the vessels engaged in pearling may not be inappropriate.

In the case of the schooners above referred to, and which are used principally as store and depôt ships, their wide range of size precludes the fixing of any average cost; moreover, it is but seldom that these boats are built specially for pearling, being in most instances bought out of some other trade as opportunity offers.

In the luggers, however, we have a class of craft peculiar to this pursuit, and calculated from their build and rig to be excessively seaworthy and fast boats. They are built in Singapore or Fremantle, and it redounds to the credit of the Colony that, from the superiority of work and material, the latter boats are usually given the preference, though slightly more costly. A Fremantle built lugger costs, on the pearling grounds, with outfit of spare sails and rigging, from £350 to £400; to render the craft complete a diving outfit, consisting of air-pump, two dresses, four lengths of diving hose and all necessary connections is requisite, costing, landed in Broome or Cossack, about £150.

When we consider the number of vessels engaged in the industry it will be evident from the prices quoted above that there is a very large amount of capital embarked therein.

Statistics of the results obtained from pearling will enable the reader to form some idea of the return given for the capital invested.

On account of the great difficulty in keeping an accurate check on all shell and pearls exported, the returns given may in all cases be regarded as somewhat below the mark.

From the sources of information available we find that during the 10 years to the end of 1898 the export of Nor'-West shells shows a total of 5,529 tons, of an estimated value of £568,232, while the pearls obtained during the same period (as by the estimate of the Customs Department of the Colony) amounted in value to £285,000; for the year 1898 the amounts are—shell 537 tons, valued at £67,548, and pearls (estimated) £20,000.

From Sharks Bay it is found that for the 10 years above specified, shell to the value of £53,098 has been sent away, while the return for 1898 was £3,040; of the pearls exported from this locality no estimate has been made.

These results cannot be regarded as other than highly satisfactory, especially as regards the Nor'-West portion of the industry.

With regard to the future of pearling in this Colony the outlook is distinctly bright; during 1899 the returns have shown an increase, and there are causes at work which promise to give the industry a still further impetus.

One of these is the introduction of the Gordon Buchanan diving apparatus, enabling divers to work with safety at a considerably greater depth than has hitherto been possible.

The experience of past years has shown that, when attempts were made to obtain shell from depths over 20 fathoms, the results have frequently been fatal to the diver, paralysis and subsequent death often ensuing: although a small amount of work has been done in water over this depth, still it is found that the short length of time for which divers are able to stand the enormous pressure of the water, and the frequent mishaps which have occurred, have rendered the task an unprofitable one: the shell, however, is as plentiful, or even more so, at this depth, and the use of any dress which will enable work to be safely and easily performed at depths of 30 fathoms or over will open up an immense area of profitable ground.

While it would be somewhat premature to make any definite statement, it may safely be said that experiments which have lately been carried out in the Nor'-West point to the early satisfactory solution of this problem.

Again, during the last two years, attention has been turned to the cultivation of the pearl oyster, and the results obtained so far show that this enterprise opens up a vista of great possibilities. During 1898 the legislation enabling persons desirous of so doing to acquire areas of water held under exclusive license for cultivation purposes has been extended to the Nor'-West, having formerly applied only to the Sharks Bay district. Advantage has been taken of these facilities, and the experiments made have proved eminently satisfactory.

Mr. Saville-Kent (formerly Commissioner for Fisheries in Western Australia, and a world-wide authority on these subjects) has shown his faith in the possibilities of this branch of the industry by the acquisition of some large areas near the Lacepede Islands, in addition to his experiments in acclimatising the Nor'-West shell around the Abrolhos Islands in the Sharks Bay district.

Again, another proprietary have secured the waters of Beagle Bay, a sheltered spot well suited for the object in view, and, not satisfied with cruder methods, have despatched a representative to Arcachon, in the South of France, a place famed for the successful cultivation of the edible oyster, to gather information regarding the methods in use there, with the idea of using the same or similar methods in the prosecution of their enterprise.

It must be patent to everyone that, if the young oysters can be protected at that crucial portion of their existence when they are practically helpless, a very much larger proportion can be brought

to maturity, and this must form the dominant idea in any scheme for the cultivation of shell. Again, it would be much less expensive and laborious to collect the cultivated shell whose locale is accurately known, than, as is ordinarily the case, to spend the greater portion of the diver's time in searching for patches of shell-bearing bottom.

For these reasons it seems extremely probable that the next few years will witness great strides onward in the pearling industry, more especially as the life is one that, from its freedom, from the enlivening spice of danger attending a seafaring existence, and from the element of luck which is inseparable from it, will never lack recruits from that class of men who, throughout the history of civilisation, have ever been in the forefront of pioneering.

Nor is the collection of pearl-shell all that this prolific coast offers to those willing to accept the gifts held out to them. From Sharks Bay Northwards its waters are inhabited by various species of turtle, including that commonly known as the Hawksbill (*Chelone imbricata*), from whose horny covering the tortoise-shell (so called) of commerce is prepared.

Spasmodic efforts have from time to time been made to turn this resource to account, and individuals have occasionally done fairly well by devoting some little time and labour to the collection of tortoise-shell, but practically no systematic work has been done so far. In addition to the species already mentioned, several edible varieties of turtle, fit subjects for conversion into that far-famed delicacy reputedly so acceptable to the palate of the London city magnate, turtle soup to wit, have their habitat along this coast, and the numerous sandy beaches on the islands fringing the coast a short distance from the mainland form huge breeding grounds for them all.

Concessions of the right to capture turtle upon certain of these islands have lately been secured by a party of persons, who are desirous of starting here an industry which has already proved fairly successful on the seaboard of Queensland, *i.e.*, the preparing, in canned form, of the more delicate portions of the turtle, and this enterprise, in combination with the collection of tortoise-shell, should no doubt prove highly remunerative.

The returns furnished by the Customs Department show that, for the ten years up to the end of 1898, tortoise-shell to the value of £1,907 has been exported from the Colony; which fact proves that even the small efforts which have been made in this direction have some tangible value.

Again, another delicacy which, though not appealing to any great extent to the European palate, commands, nevertheless, a ready sale in the Chinese and East Indian markets, is found in these waters in the form of bêche-de-mer.

This product is furnished by several species of the numerous family of *Holothuria*, commonly known as the sea-slug, and some

of the best varieties occur fairly plentifully on some of the more Northerly portions of the coast of the Colony.

As in the case of tortoise-shell, but little straightforward work has been done in the working of this branch of the fishing industry, but sufficient has been accomplished to show that, in the production of this article, the Colony has at its gates a valuable asset which needs but judicious application to turn to good account.

It is found by the Customs return that the export of bêche-de-mer for the ten years ending 1898 amounted in value to the sum of £6,760.

The whole of the very extensive coast line of Western Australia is plentifully stocked with fine varieties of edible fish, and offers splendid opportunities for the acclimatisation of yet further species, esteemed in other lands but unknown in this. Within the necessarily short space of an article of the present description, it is impossible to do more than to touch in the most desultory manner on subjects that would well bear further elaboration, yet if sufficient has been here written to prove that, along her extensive sea-board, Western Australia possesses resources fitted to rank, not disproportionately, with the undoubtedly rich mineral and agricultural assets even her present developments have disclosed, then the firmly settled belief of the writer will have had tangible expression, and the purpose of the present article will have been fully served.

Number of vessels employed, 168; tonnage, 2,212. Labour employed—whites 65, aboriginals 91, Chinese 5, Japanese 182, Malay 328, Manillas 239, others 55, making a total of 965. The quantity of pearl shell, 639 tons 16cwt. 22lbs., value, £11,202; value of pearl shells, £69,438. Bêche-de-mer, 20 tons, value £1,300. These figures are for 1898.

PANORAMA OF THE CITY OF PERTH.

MANUFACTURES.

(*By E. J. Bickford, M.L.S., President Mueller Botanic Society.*)

It is generally recognised in all civilised countries that, in the march of progress of a new Colony, agricultural pursuits claim first attention.

If a country in parts should be of an auriferous formation, there are those with a geological knowledge who determine the existence or otherwise of precious minerals, and should it be discovered that gold or other ores exist in payable or large quantities an inrush of population is sure to set in, and this has been the experience of Western Australia during the last few years.

Following upon the rich gold discoveries of 1892, auriferous belts have been opened up throughout the greater portion of this vast Colony, and the strides made by this particular industry have been so rapid as to have already placed it in the front rank of the leading gold-producing countries of the world. The population has more than trebled itself within the past four years, but prior to that period little or nothing had been done in regard to the development of manufactures. So surely, however, as gold claims second attention, and is sought after by eager prospectors, so also do manufacturers in turn find that it is their opportunity to commence active operations in order to manufacture all that they possibly can of the requirements of the people living within the Colony.

The latest Statistical Returns issued by the Government of Western Australia distinctly show the marvellous developments which are taking place in the Colony's trade, and the splendid opportunities thereby afforded to experienced men, who have a knowledge of their various manufactures, to commence business on a sound basis and with unlimited prospects.

It is noticed by manufacturers throughout the world that what is most required to compete in the outside markets is cheap fuel, a fair rate of wages, and easy means of transit. It has been rather unfortunate for those engaged in the manufacturing industries of this Colony that in this direction it has not been all that could be desired, as it is only to be expected in all new countries, where people are anxious to make their fortunes in a short space of time, that artizans are disinclined to engage in their various trades, but prefer rather to explore the goldfields first, and as is invariably the case many fail to secure that measure of success they desire, with the result that they return in quest of a livelihood at the trade

which they had left. This has been the experience of a number of manufacturers here in connection with their workmen, and they have been thereby seriously handicapped for the time being.

It may be interesting to touch upon the surprisingly large number and varied industries now existing in different parts of Western Australia. Most of them are practically of new birth, but a few have struggled for many years, and, with the development of the mining and agricultural resources of the Colony, the manufacturing industries are destined at no distant date to mark a most important feature in the Colony's progress.

In October last year an exhibition of local manufactures was held in Perth, at which there were to be seen nearly 150 sections, and it was remarked by visitors to the exhibition that they were indeed surprised to see such an excellent display of superior goods manufactured in Western Australia, whilst the committee responsible for the exhibition expressed their gratification at being associated with it. The exhibits were got together within six weeks from the time the exhibition was first initiated, and it reflected great credit upon the manufacturers in showing the incredulous public the extent of these young industries, the products of which they were endeavouring to place before the public through the medium of the exhibition.

In the vast number of exhibits it was particularly noticeable that an industry which should have held a prominent place in West Australian manufactures was not in any way represented, viz.:—ready-made clothing; clearly showing that very little has been done up to the present in this large and extensive avenue for the profitable employment of both labour and capital. The returns show that no less a sum than £258,000 was sent out of the Colony for the purchase of goods of this particular manufacture during 1897.

These remarks, however, cannot be applied to the boot and shoe industry, for we have now in our midst some very complete factories, the proprietors of which commenced in a small way some two or three years ago, and are now finding employment for a large number of men and women and the youth of our Colony in this industry. The latest machinery and every modern scientific improvement have been introduced for the perfection of the work; but, notwithstanding this, it was clearly demonstrated at the Exhibition, at which there was an excellent display of manufactured boots and shoes, that many persons were under the impression that the boots they were wearing were of foreign manufacture, until they saw exhibits precisely similar of local production. It is no doubt due to prejudice and want of knowledge for the public to say that good boots cannot be made in the Colony, and this lack of faith is responsible for the fact that over £100,000 is being annually expended outside Western Australia for this particular commodity.

Much has yet to be done before we can manufacture all the mining and agricultural machinery required throughout the Colony. There are firms who engage a large number of hands for local

requirements only, and they are endeavouring to secure the bulk of the trade, and, consequently, have made their plants perfect with all necessary and up-to-date appliances to accomplish this object. They cannot claim, however, to have supplied anything like the demand in this respect when we find so large a sum as £230,000 being remitted to other countries in one year.

In regard to Furniture, little was done in local manufacture until within the last two or three years, when furniture dealers turned their attention more particularly to manufacturing in the Colony rather than importing, with the result there are now some important establishments where men are to be seen constantly engaged in the manufacture of furniture in all its branches.

Coming to the Hat and Cap industry, which is represented in the list of manufactures in the Colony, local producers are confronted with the fact that they are not supplying our own market up to the present by something like £20,000 per annum.

Soap and Candles formed a very important feature of the Exhibition. There are several firms engaged in the manufacture of these useful household requisites, and they have a large number of people employed in their production. The amount spent annually outside the Colony for these goods reaches the large sum of £21,000.

Our local cigar makers complain that the consumer is prejudiced against the product of this particular industry, and they are endeavouring to produce—in fact, they are producing—a cigar equal to the best imported, and are anxious to see the time when the sum of £31,600, annually sent away for the fragrant weed, will be circulated within the Colony.

Over £52,000 worth of jams, jellies, and preserves was imported during 1897, and the reason this large amount is not circulated in Western Australia is probably because the manufacturer has to pay an exorbitant price for fruit. It is evident, however, that before many seasons elapse fruit will be one of the cheapest commodities in Western Australia, and this is obvious in view of the great success attending the experiments and developments made by many of our enterprising orchardists, who are clearly demonstrating that this is beyond doubt an essentially fruit-growing country. The manufacturers will then be placed in a position to purchase fruit at a price which will enable them to compete in the outside markets.

Why fancy cake cannot be manufactured in Western Australia is a question that might well be asked, when we consider that the various ingredients used in its manufacture can be secured here as cheaply as elsewhere. Under these circumstances it seems incredible that a sum of £20,000 should be sent away to other places for this article of food. It seems equally unsatisfactory that we cannot manufacture, within our border, all the biscuits that we require instead of having to import £11,000 worth annually. It would

seem that a monopoly, to some extent, is held by manufacturers in the Eastern colonies, who have spent a large amount of money in advertising their wares. It may not, however, be generally known, but it is a fact nevertheless, that we have existing in Western Australia one firm, at least, who are endeavouring to prove to the public that they are in a position to manufacture cake equal in quality to that which is imported, and to sell at the same price, but for the reasons above mentioned are unable to secure, as yet, that fair share of our own market to which they are justly entitled.

There are several firms engaged in the manufacture of Sweets, the importations of which exceed £10,000 annually, and yet they experience great difficulty in commanding a local trade for their manufactures, which are equal in every respect to imported goods, while the raw material used is the best procurable in the world. The machinery is of the most modern type, and the men engaged in the factories have, for the most part, gained their experience in the leading establishments in the old country in this line of trade.

Although probably not so important, we find other industries capable of large development in our midst, such as Stationery and Bookbinding, Tinware, Sauces, Baking Powder and Condiments, Pickles, Cardboard Boxes and Paper Bags, Picture Frames, Mantel-pieces, Vinegar, Venetian and other Blinds, Cooperage, Vehicles of every description, Saddlery, Brushware, Girders, Iron Safes and Fancy Ironwork.

What might be one of the most important industries of the Colony has so far been neglected, but it is to be hoped that some enterprising manufacturer will establish engineering works for the production of railway rolling stock of all descriptions. The timber used in the manufacture of railway carriages, trucks, vans, etc., can be largely obtained from our local forests, and it is reasonable to suppose that the local manufacturer would receive the bulk of the Government orders for such stock. According to the latest returns available, it is shown that sums have been expended in that direction in one year amounting to nearly half-a-million sterling.

Every encouragement is given by the Government, as far as practicable, to those engaged in manufacturing pursuits in the Colony. Moreover, the facilities available in respect of perfect harbour accommodation, far-reaching railway service, and the development of extensive coal deposits are such as to demonstrate to the manufacturer that this Colony, with its 1,000,000 square miles of territory, possesses all the advantages of a progressive country.

PUBLIC WORKS AND RAILWAYS.

There is no department of the administration upon the shoulders of which a greater burden of responsibility has been thrown than that of the Public Works and Railways. The era of Responsible Government, inaugurated just a decade ago, became, by a remarkable coincidence in the history of Western Australia, the herald to a dawn of prosperity and national development as has seldom fallen to the lot of any young country in modern ages. Gold has ever been the readiest magnet to attract population. With the auriferous discoveries in the early nineties came a flood of populace spreading over the face of the country like a tidal wave, touching with its outermost ripples the remotest points of the vast interior, hitherto only seen by the pathfinders whose trips of exploration had involved danger and difficulty, time, labour, and expense. Wherever gold was found there was planted the nucleus of settlement, requiring facilities for transport and approach, the opening up of highways, provision for water supply, the protection provided by the law, and the concomitants of nineteenth century civilisation. The Government manfully grappled the task, and set itself to equip a barely accessible territory, embracing many thousands of square miles, with roads, wells, dams to conserve the scanty rainfall, railways, telegraphs, housing for its officials, ports on the seaboard, and a multitude of public works executed in the shortest time at an outlay in money gigantic in comparison to population at that early date, employing and controlling an army of men in its prosecution with skill and determination throughout its conduct.

One of the earliest tasks with which the Government found itself face to face, and which it set itself resolutely to overcome, was the solution of the transportation problem. In a country of such vast extent, devoid of waterways, with a promising mining industry springing up inland many hundreds of miles from the base of supplies on the sea coast, the enormous cost of hauling up all supplies in the shape of food, timber, and fuel for the mines, building material, machinery, and, indeed, every commodity needed in the conduct of daily life, proved such a brake on the wheel of progress, such a heavy tax on the chief industry of the Colony, that speedy relief in the shape of transport facilities was recognised as a *sine quâ non*, both to the successful prosecution of gold-mining, as also to agricultural development and commercial expansion. A spirited railway policy was inaugurated and has been maintained since, as the only means of opening up the great back areas of auriferous territory, as well as the vast timber forests, agricultural districts, coal and mineral

belts, and bringing them within the sphere of profitable commercial development. No new country possessing such an enormous area of territory, and containing (in the aggregate) merely the population of one old-world city scattered over its huge surface, ever built and equipped such a length of railage in so brief a time, and, more to the point, made it pay handsomely, as Western Australia has done.

In addition to that great project which the Government has in hand, the Coolgardie Water Scheme, for supplying water at a low cost to a portion of our Eastern goldfields, the Public Works Department has in hand the work of opening up our stretches of auriferous back country by equipping its roads and settlements with wells, dams, tanks, and water reservoirs generally, the fulfilment of which has called for a large outlay in money, labour and skill.

The absence of water, and the scantiness of the annual rainfall, constitute the bane of the Australian interior, rendering settlement and commercial progress impossible until remedied and water on a large scale is provided for population and industry. The area is great, and the administration and maintenance necessarily costly.

Wherever, on these arid stretches, the search for gold has led to settlement, reservoirs have been constructed for the conservation of the scanty rainfall which would otherwise be quickly absorbed by the sandy soil or evaporated by the sun's heat. A novel feature in the art of water conservation, brought into existence by the exigencies of local conditions in Westralia, is observable where well water is either salt or impossible to obtain. At intervals in the sun-stricken bush the underlying rock protrudes itself through the surface in gigantic masses of rounded granite boulders, often over a hundred acres in extent, smooth and bare. The scanty rainfall runs off these and is lost in the porous soil aronnd the base, benefiting none.

However, engineering skill, seeing its opportunity, has treated the bald outcrops like house roofs, and has built a stone and cement wall and gutter completely around the rocks near their base, so that the water, as it falls, is caught and conducted from every point to an excavated tank in a convenient locality, and saved for use. Railways, townships, and the travelling public are supplied with the elixir of life in this fashion.

In addition to this, wells have been sunk and pumps erected, and where fresh water was absolutely unobtainable condensers are maintained, retailing water at a low cost.

The country from Cape Leeuwin, on the South, to Geraldton, on the North, and from the Darling Range, along its Eastern boundary, to the sea coast on the West, forms a great artesian basin, which has been tapped by numerous bores, from which, in most cases, an abundant supply of water has been obtained for purposes of general utility.

Another great work of the Department has been to provide jetties and conveniences for the loading of cattle and sheep over a coast line of 1,200 miles, stretching from Eucla on the South

Australian border, to Wyndham in the North, a very necessary task in opening up the country and affording facilities of ingress and egress to the pastoral industry. The great distance over which this work is of necessity scattered renders it arduous and expensive, but the country has benefited correspondingly.

The programme carried out by the Architectural Division of the Public Works Department has been a very heavy one. Practically, the whole of the goldfields and new agricultural settlements, with the growing centres from the far North to the extreme South, had to be equipped with public buildings in the briefest space of time, and of sufficient size to meet the needs of present population and future prospects.

From whatever point of view it is regarded, the Coolgardie water supply scheme must be considered a gigantic undertaking for a young colony with so sparse a population and such comparatively undeveloped resources available for carrying the financial burden involved in its consummation. As an engineering achievement, too, it is a bold conception, involving the pumping of 5,000,000 gallons of water a day through a steel pipe, from an artificial reservoir in the Darling Ranges, 325 miles over hill and dale to Coolgardie.

The provision of a fresh water supply adequate to the demands of an increasing population is not only a desideratum in the interests of comfort and civilisation, but is also an absolute necessity in the arid zone in which our principal gold camps are built. Communication, transport, ore reduction, and life itself, depend on a plentiful water supply, and Nature having been unpropitious in this regard, it remains for human enterprise to step in and remedy her defects.

Water is required on the goldfields for drinking and sanitary purposes, and for the production of gold. The actual number of dividend-paying mines is not yet large, while the average yield of the precious metal per ton of ore treated is distinctly high in comparison with mines in all other parts of the world. The profits, in fact, are eaten up in the cost of production. There are scores of fairly well proved mines that will yield, say, 10 pennyweights of gold to the ton. It now costs 11 to work them, and they lie idle, but so soon as they can be worked for nine pennyweights just so soon are capital and labour available to develop them to the good of all concerned, giving employment to many, adding to our gold output, and enriching both their owners and the country.

Water, such as it is, is found in many places on the Eastern goldfields, but even where the supply is adequate for the demands made upon it, it usually contains such an excessive quantity of saline impurities as to be practically worthless, without the costly process of condensation. Batteries for ore reduction are therefore not erected at all in many places eminently adapted for them, or, if set up, are frequently compelled to stand idle, or be absolutely abandoned for want of water.

The Government of the Colony has thoroughly grasped the necessity of overcoming this difficulty, in proof of which they stand pledged to the construction of the necessary works to carry fresh water from the more favoured coastal regions up into the arid districts of the auriferous interior. The credit for the conception of the great water scheme, its design and engineering details, is due to Mr. C. Y. O'Connor, C.M.G., the Engineer-in-Chief of the Colony, while the Legislature has placed its *imprimatur* on it by sanctioning the raising of a loan of two and a-half million pounds sterling to cover the cost of construction. This is a large amount of money for a small colony to sink in one single work, but the absolute necessity of some artificial means for supplying the Eastern goldfields with water on a large scale is so thoroughly recognised and admitted (and without it the output of the Colony's staple industry must be so materially impeded), that all objection to the work on the score of magnitude must fall to the ground. The Premier, Sir John Forrest, has contended with forceful reason that the great work is a reproductive one, that the charge that is to be made for the service of water on completion (which will be, however, but a small fraction of the charge made in Coolgardie for the present scanty, precarious, and otherwise unsatisfactory supply) will more than cover cost of maintenance and interest on loan capital raised for construction. This contention is based on reliable statistics, and may therefore be safely accepted as correct.

When this large project which, both on account of its originality of conception and its magnitude, will certainly attract attention outside the Colony, was first mooted, it met with considerable local distrust and some direct opposition. In view of the great cost and the large hypothecation of the country's resources involved in constructing such a work with borrowed money, it was deemed advisable by the Government to refer the scheme to certain eminent English Engineers for report. Accordingly, and for this purpose, the services of Messrs. John Carruthers, George F. Deacon, and William Cawthorne Unwin, acknowledged authorities in regard to such works, were commissioned. In due course these gentlemen have presented an interim report which, although cautiously worded, is certainly not adverse to the scheme. On the contrary, this is their general statement as to the practicability of the scheme :—" It has been rightly assumed by the Government of Western Australia and their advisers that the scheme as propounded is quite practicable. Water has been successfully pumped under much greater pressures than will be necessary in this case, and has been passed through pipe aqueducts in much greater volumes. We are satisfied, however, that with proper precautions in the design and manufacture and use of pipes and joints, any danger of failure or serious loss from leakage may be avoided. Subject to these and to other precautions which we shall indicate, there can be no doubt that the scheme—if properly worked out in detail on the drawing-board, and adequately described in binding specifications,

Coolgardie Water Scheme. Helena Dam.

and subject, of course, to due and continuous inspection of the work—may be carried out with the certainty of success."

As the general feasibility of the undertaking was the point about which doubt was mostly felt when the scheme was first put forth, the report must be considered to have settled the question of practicability.

No objection has ever been raised to the project on the score of sufficiency of supply at the source of water conservation. The rainfall on the Ranges near the coast, where the reservoir is being constructed, is ample. This reservoir will practically dam the Helena River, which, taking its rise in the Darling Ranges, finds its way into the Swan River, near the sea. Here the whole undertaking will start, and hence the mines and towns on the Eastern goldfields are to draw their supplies of fresh water. The service to Coolgardie will be but the beginning of an undertaking having for its full and ultimate purpose the provision of a supply of water to all the mining centres on the Eastern goldfields, and an essential requirement to the working of the mines there to the best advantage.

The aqueduct is to follow the general line of the railway, facilities thus being provided for the carriage of the pipes and machinery from the coast, while the advantage of having the several pumping stations close to the railroad is at once apparent.

In estimating the measure of her future growth, the geographical position of Western Australia must be considered as a factor of first importance, for when the demands of a somewhat restricted home market have been met and surpassed by local supply a market abroad to absorb surplus production will be a *sine quâ non* to industrial expansion. What has happened with the other colonies will shortly eventuate in the case of Western Australia, and it will be then that the many advantages of position in geographical relation to the outer world which this Colony enjoys will receive a degree of recognition hardly as yet felt or appreciated. The position of Western Australia is more favourable for inter-communication with the rest of the world than that of her sister colonies, because she commands the islands of the Indian Archipelago, and routes to Singapore, Siam, and China. Moreover, on the great ocean routes to the West she has precedence even of South Australia by more than 1,000 miles to Ceylon, Burmah, and consequently all India, Bombay, Persia, and by the Red Sea, Egypt, and Arabia, and by the Mediterranean, with all Europe and North Africa; while, by the Cape of Good Hope, she has the same advantage in communicating with both coasts of the Atlantic, and its islands. The Mauritius and West coast of Africa are still more accessible, so that she may be content to leave to the Eastern colonies the command of the Pacific, from New Guinea to the Western coast of the American Continent.

In fact, Western Australia commands, by virtue of its latitude and longitude, the Dutch and Portuguese East Indies, the Straits

Settlements, Hong Kong, the New American Territory in the Philippines, and all the Southern portion of Asia, the most populous region of the earth's surface,

With such limitless possibilities for trade and external commerce ahead of her, it follows as a natural corollary that ample shipping facilities where tide and rail meet must be provided at all costs. Fremantle, as the principal port of the Colony, the terminus of the projected transcontinental railroad, the point from which diverge the steel arteries of the country's commercial life-blood, fulfils the requisite conditions, and, for some years, neither money nor engineering skill has been spared to render the mouth of the Swan River a safe haven for the shipping of all nations, the first and last port of call for the Australian Continent.

Without internal communication, the defence of a vast Continent such as this is practically impossible. We may therefore expect that the Federal Government will seek at an early date the power to construct a great railway to connect the systems of the East with the present line pushed out from Fremantle to Coolgardie, Kalgoorlie, and our goldfields.

Such a line will make Fremantle the port of landing for all mails from Europe. All imported goods requiring speed in transit rather than economy in freight will be landed there, making of Perth and Fremantle two of the most important places on the Continent, becoming the points of arrival and departure for passengers and goods traffic. Every town on the line of the railway will benefit, besides which, our goldfields will be on a direct track of commerce instead of, as now, isolated and remote. Unless this line is built, we shall have a Commonwealth with obligations of defence which it cannot possibly fulfil.

The route from London to Sydney, *via* Fremantle and overland, is only 11,843 miles, Fremantle to Sydney, *via* Port Augusta, Broken Hill, and Cobar, requiring a line of rails 2,100 miles long. By this route mails could be delivered in Sydney in 27 days 18 hours, whereas by the present sea route the distance *via* Adelaide is 13,103 miles, and the time roughly speaking, 31 days 6 hours. This shows a gain of rail over sea of 1,260 miles. No matter from what standpoint we view it, or with what arguments we assail it, the position of Fremantle is beyond dispute.

Having examined the position of our chief port geographically and commercially, it remains to be shown what has been achieved by human skill and enterprise in making the best of the material to hand, and in overcoming the natural difficulties in the way of successful consummation of the project the Government of Western Australia has set itself to accomplish.

From the very inception of the Colony of Western Australia, Fremantle has been its principal port of ingress and egress. On 6th March, 1827, the "Success," spying out the land with a view to the possibilities of settlement, dropped anchor at the mouth of the Swan River and sent a boat's crew to inspect the entrance.

The report was unfavourable. A continuous bar of rock and sand denied all hopes of a passage to ships, grudging even a shallow channel to a row-boat. Once over the bar, from four to ten fathoms of water was found. Thus in the earliest days were the natural difficulties in the way of forming a safe haven for shipping at the mouth of the Swan River recognised. In the thirties, small boats plied from the humble jetty in the shallow basin to the ships anchored off the port, passengers being often carried ashore on the backs of men wading through many long yards of mud. In 1839 Surveyor-General Roe, at a time of the vigorous prosecution of a spirited public works policy, drew up the specifications of a mole harbour at Fremantle, which he estimated would cost, at the ruling rates of labour and materials, £57,767. He shrewdly added to his report that the work could be done for half the money by obtaining 1,000 picked convicts from London. It was projected to afford mooring accommodation for 12 ships. The financial magnitude of the scheme staggered the authorities. It was far beyond the means of the Colony, and was allowed to lapse.

In 1848, under Governor Irwin's *régime*, a sum was placed on the Estimates for the purpose of cutting through the bar by blowing up the rock with dynamite, so as to effect a passage for small vessels. Beyond deepening the river in places nothing of a material nature was accomplished, for the bar sternly defied all efforts to burst it asunder.

For 20 more years Nature held undisputed sway, defying such resources of art and skill as were available for her subjugation. Numerous proposals had been submitted for rendering Fremantle a safe harbour for shipping; various engineers had attempted to perform the feat, but the bar remained obdurate. In 1870 Mr. Doyne, C.E., and in 1873 Mr. Wardell, reported on the question after careful investigation, it being deemed impracticable to accomplish the opening of the mouth of the Swan. In 1870 Captain Croke and Surveyor Cowle took the soundings in Gage Roads. A few years later the various plans and reports for the construction of a harbour were submitted to Sir John Coode, the eminent expert, for his opinion, which was eventually an unfavourable one.

In the early eighties numerous proposals were placed before the Government to construct railways on the land-grant system, including an elaborate scheme from Sir Julius Vogel and Mr. Audley Coote to build to the South Australian border and to make a harbour at Fremantle at the Western terminus of a transcontinental line. The antipathy of South Australia to land-grant railways frustrated the scheme, though public opinion was keenly aroused as to the importance of such a proposition as making Fremantle the principal port of the continent on the Western coast.

Sir John Coode's plans embraced two alternative schemes—the one securing 29ft of water in a safe anchorage, at a cost of £638,000; the other giving 20ft., at an expenditure of £242,000. The various offers to build railways to Eucla were, of course, dependent on the construction of a safe harbour at Fremantle. Careful surveys were made in 1886, and Sir John Coode visited the

Colony, at the invitation of the Government, spending five weeks in a close inspection of the mouth of the Swan. In his report he expressed the opinion that the difficulties attendant upon the formation and maintenance of suitable and safe approaches in Cockburn Sound were so great, and would entail such a large expenditure, that there would be no alternative but to consider the utilisation of the shelter and deep water as entirely unattainable. It had been proposed to construct a river entrance and a canal to Rocky Bay. Of the erection of moles, Sir John Coode said that the cost of such sheltering works would considerably exceed that of suitable structures adopted to meet the required wants if undertaken in the proper positions, and was therefore inadmissible. There was a grave objection to a corresponding treatment of the existing entrance to the river; for, in consequence of the very limited volume of tidal and back water available for scouring purposes, there were strong grounds for anticipating that a sand-bar would grow up at the improved entrance, which would in all probability seriously prejudice its practical utility. He did not think the Rocky Bay project was feasible. To provide, he continued, for the unimpeded movement of the sand, it would be requisite that any sheltering work at Fremantle must be detached from the mainland, connection with the shore being effected by means of an open viaduct so arranged as to admit of the unrestricted passage of the sand without causing its deposition. The Government, in view of this unfavourable report, did not determine for some years upon any elaborate scheme of harbour works, though the matter was by no means allowed to drop.

A year or two later, the Colony being in a stronger financial position, with the promise of increased population and prosperity, the Government faced the problem once more with persistency and determination. The urgency of secure harbour accommodation at Fremantle increased in direct ratio with the growth of the Colony. Sir John Coode was again communicated with, and he approved of opening a passage through Success Bank into Owen Anchorage, and through the Parmelia Rock into Jervois Bay and Cockburn Sound, if necessary. The Government at first favoured the construction of a harbour at Owen Anchorage, connecting it by a short railway, a mile-and-a-half in length, with Fremantle. Mr. C. Y. O'Connor, the Engineer-in-Chief, advocated the construction of moles running out into the sea at Fremantle. He did not anticipate any probability of danger from sand-travel. In the absence of any artificial mole or abrupt headland there was no positive proof. Any accumulation, however, could be counteracted by dredging. His scheme included the erection of two breakwaters, extending from Arthur and Rous Heads at either side of the entrance to the Swan River and the excavation of a channel, between the two moles, through both rock and sand. An inner basin was proposed to be excavated, and wharves, stores, and sheds constructed.

The estimated cost was £560,000. An amplification of the scheme to complete it fully involved further excavations in both the

inner and outer channels, and the prolongation of the wharves, which would bring the cost up to £800,000. Other engineers of wide repute expressed opinions favourable to the entire feasibility of Mr. O'Connor's project, and indorsed his views as to the question of sand-travel. The two schemes were taken in hand and debated by the Government, by Parliament, and by a Joint Committee of the two Houses, and it was formally decided in 1892 to accept that of the Engineer-in-Chief.

Prompt action followed the authorisation of the scheme by Parliament. The work was put in hand at once, and on 16th November, 1892, Lady Robinson, the wife of the late Sir W. C. F. Robinson, G.C.M.G., then Governor of the Colony, tipped the first truck of stone for the formation of the North Mole, in the presence of a large and representative gathering.

Thus it became the happy province of Responsible Government to take in hand the practical solution of a problem, old as the Colony itself, that had baffled past administrations and had been a more or less burning question since the good ship "Success" dropped anchor off the bar of the Swan River in 1827. The scheme was designed to provide a safe and commodious harbour at Fremantle, big enough to berth in security the leviathans of the trans-oceanic lines of mail steamers plying to Australia; to make the chief port of the Colony the first and last port of call of the entire continent also, and to prepare in advance the Western terminus of those bonds of steel that must at no very distant date bind East and West together, and make the tedious journey to the capitals and centres of the other colonies no longer a matter of miles to be traversed, but a question of time to be annihilated.

Large limestone quarries were opened up at Rocky Bay, on the Swan, whence a short line of rails was laid to the proposed moles, the stone being tipped without further handling into the sea.

Active progress has been since maintained, under the control of the designer of the scheme, Mr. C. Y. O'Connor, M.Inst. C.E., C.M.G., the Engineer-in-Chief of the Colony, with what degree of success present achievement will record better than words. Within a few brief years, with the comparative limitations of a young and sparsely peopled community, the traffic of the Port has gradually been transferred from the roadstead and its jetties to the quays and wharves along the banks of the river, where at the present time vessels of the largest burthen lie in safety at all states of the tide.

The three following articles: "The Railways of Western Australia in 1899," by John Davies, General Manager of the Western Australian Government Railways, and "The Fremantle Harbour Works," and "The Coolgardie Water Scheme," by C. Y. O'Connor, C.M.G., Engineer-in-Chief, will convey succinctly to the reader an official account of the principal public works of the Colony.

THE RAILWAYS OF WESTERN AUSTRALIA IN 1899.

(By John Davies, General Manager of Government Railways.)

To those who speculate as to the character and state of development of a new country with which they are unacquainted, the means of communication by railway will, perhaps, afford one of the best mediums of judging of the extent to which civilisation has spread itself over the face of the land. Those who regard it as a possible place of residence will no doubt wish to assure themselves of the facilities of transit available from one part to another for business or pleasure, or as a means of conveyance to or from the centres of population. Those who regard the industries of such a country as a likely field of profitable investment will doubtless desire to look into the matter with a view of ascertaining the extent of the facilities which assist the progress of production, and which, if satisfactory, cannot but aid the economical and successful working of any venture in which they may feel disposed to place their money. Railways bring comforts and cheapness of living. They assist every industry; and they may be regarded perhaps as the most reliable basis on which to found an opinion as to the state of prosperity and commercial activity of the country they serve. They are the pulse of the nation, and by the throbs of their traffic the industrial condition may be judged.

It may be said that it is in regard to her railways more than in any other artificial respect that the Colony of Western Australia is well favoured. Taking a population basis, she has a greater railway system than any other country in the world, as for every 133 inhabitants one mile of railway line is owned and worked by the State. The statements hereinafter contained will reveal the expenditure which this small population can afford in transport, and from them may be deduced the spending power and prosperity of the people and industries of the Colony. From the fares and rates quoted it will be seen that the result shown is not swelled by any undue highness in charges, but is due entirely to legitimate trading and to the natural wealth of the country.

But, to be practical, one must resort to figures and facts; and, firstly, let us take the facilities afforded to passengers. There are two classes of carriages only; the vehicles, built in England, approximating in design and comfort very nearly to those used there and on the Continent. The principal differences which one notices are that the carriages are not quite so broad, owing to the gauge of the rails being slightly narrower, and necessitating a maximum of six and eight passengers per first and second-class compartment respectively; that a double roof covers the carriages; and that all the windows (six in each compartment) can be opened or shut, these latter arrangements being made in order that the utmost extent of coolness may be attained in the carriages during the heat of the summer months. On all trains where long journeys are undertaken, carriages with a lavatory opening out of each compartment are provided in both classes; and on night journeys first-class passengers may, on payment of a small fee, book a berth in one of the "sleeping" compartments, which also have similar conveniences. Stoppages for refreshments are allowed for in the time-table at convenient times and intervals, refreshment rooms forming part of

the buildings at certain of the stations. These are leased by the Department under conditions which ensure every satisfaction to the travelling public, cleanliness, the best quality of food, combined with particularly moderate charges, being the primary objects of the leases.

The lavatory and sleeping cars are fitted with electric light, which the passenger can turn on or off at pleasure, and thus the tedium of travelling after sunset is greatly relieved, the light afforded being such as to enable reading to be indulged in with ease and comfort. This means of lighting is being gradually fitted to all passenger vehicles, and affords great satisfaction.

The basis of the ordinary fares is 2d. per mile for first and 1¼d. per mile for second-class passengers, except in the metropolitan or suburban area, where fares are slightly lower. Below are given a few instances of passenger fares, and, no doubt, when they are compared with the charges in other countries for journeys over similar distances and for a similar class of carriage, the reader will be surprised at their comparative cheapness.

Miles. (One way only.)	Between	Single Fare. 1st Class. s. d.	Single Fare. 2nd Class. s. d.	Return Fare. 1st Class. s. d.	Return Fare. 2nd Class. s. d.
12	Perth and Fremantle ...	1 9	1 0	2 6	1 6
66	" " Northam ..	10 9	6 8	16 2	10 0
115	" " Bunbury ...	18 11	11 9	28 5	17 8
236	" " Southern Cross	39 1	24 4	58 8	36 6
375	" " Kalgoorlie ..	62 3	38 10	93 5	58 3
872	Albany and Cue	145 4	96 5	218 4	144 8

Return tickets for distances over 15 miles are available for return within a week of date of issue; over 50 miles within two months; and over 200 miles within three months. It will be noticed that the return fares are calculated at one half of the charge for the outward journey.

During the summer months, at holiday times, or on any special occasion which may arise, and which may tempt the public to travel, excursions at very moderate rates are run. For the sake of example the undermentioned fares are quoted, taken direct from the handbills announcing them:—

Distance (miles).	Between	1st Class. s. d.	2nd Class. s. d.	Occasion.
1,208	Menzies to Busselton ...	83 2	51 10	Ordinary daily
750	Kalgoorlie to Perth ...	64 3	40 10	Summer Excursion.
912	Southern Cross to Albany	70 4	43 10	Goldfields to sea-side.
726	Fremantle to Coolgardie	31 0	21 0	Coolgardie Exhibition, 1898, including admission.
1,142	Albany to Coolgardie ...	41 0	31 0	
1,050	Bridgetown to Coolgardie	41 0	31 0	
254	Fremantle to Bunbury ...	15 0	7 6	Christmas, Easter, or other special occasions.
322	" " Busselton ...	20 0	10 0	
780	" " Albany ...	30 0	20 0	
	All stations to Guildford	Single fare for return journey		Royal Agricultural Show.

The usual concessions allowed in other countries in regard to season or periodical tickets, workmen's tickets, theatrical or other similar companies, are in force on the West Australian Railways; and reduced fares are also granted to members of the local press, ministers of religion, persons attending conferences or other meetings of like nature. Commercial travellers also enjoy certain privileges, children attending State schools are carried free, and every means by which trade can be facilitated, the interests of the people fostered, or the comfort of passengers enhanced, are fully considered. Luggage to the weight of 112lbs. is carried free for each first-class passenger, and 84lbs. for every second-class passenger. Parcels are booked by passenger trains on the usual conditions, and cloak rooms and other conveniences are provided at all the principal stations.

In regard to goods traffic, as in the passenger department, the rates generally are as low as, or lower than, those in force in any of the other Australasian colonies—in fact, in the opinion of many, the charges err on the side of cheapness. Below are given what will no doubt illustrate these points more vividly than a mere statement, viz., the charges on a few groups of merchandise between different distances. In considering these I will again ask anyone who may be sufficiently interested to compare them with the rates for the carriage of goods between *non-competitive* points of similar distances, even on the old established railways of thickly populated Europe or America.

	10 miles.		100 miles.		300 miles.		400 miles.	
	s.	d.	s.	d.	s.	d.	s.	d.
Pig iron, bricks, road metal, local timber (for all purposes), per ton	1	8	7	1	15	5	19	8
Cattle food, seeds, fruit, garden and agricultural produce, oatmeal, local wine, contractors' plant, per ton	2	6	10	10	23	4	29	7
Wire netting or fencing wire, roofing slates, cheese or jam (local), per ton	4	2	12	6	29	2	37	6
Agricultural machinery, boilers, iron goods, per ton	5	0	28	4	70	0	84	7
Kerosene, linoleum, fish and meat in cool storage vans, per ton	6	6	39	2	89	2	105	10
Safes, explosives, light goods, furniture, per ton	9	2	55	10	130	10	155	10
Local agricultural produce, Up journey only (special rate), per ton	2	6	9	0	13	6	15	6
*Milk or cream (special rate), per gallon	...		...		...		...	
†Local (Collie) coal and gold-bearing ores of under 2oz. of gold per ton	...		...		...		...	
‡Firewood	...		...		...		...	

* Up to 25 miles, ½d.; 50 miles, ¾d.; 100 miles, 1d; 150 miles, 1¼d. Over 150 ¼d. for each additional 100 miles. † ½d. per ton per mile. ‡ 6d. per truck (8 tons) per mile.

The policy adopted in fixing the rates throughout has been the greatest encouragement of all industries carried on in the Colony, consistent with a small margin of profit. Thus agriculture has been favoured particularly with low rates on all farm and garden products. Timber, coal, and firewood also are carried at specially low rates, while gold-bearing ores from the goldfields for smelting at Fremantle are similarly benefited. The lowness of the rates throughout combine in giving advantage to the population of the goldfields by enabling mining material, food, and other merchandise to be delivered in their midst with the minimum increase in price for expense of carriage, and thus production in all its forms receives encouragement. The fares and rates above have been taken haphazard from our Rates Book, with a view of giving some idea to those interested of the actual charges which they would be called upon to pay either for themselves or for their goods were they resident in Western Australia. To make a detailed comparison with other countries would be invidious, and perhaps impossible, owing to the variety of the conditions obtaining; but generally, as I have previously said, it may be accepted that fares and rates in this Colony rank with the lowest of any in force in Australasia.

The consideration of these passenger fares and goods rates will justify, I trust, the statements contained in the opening paragraphs of this pamphlet. To those inclined to leave the over-populated districts of Europe or elsewhere, and to make their homes in a country where perhaps the struggle for life is not so keen, where the conditions are freer from that close competition, and the reward of labour is higher, the facilities afforded by the railways of Western Australia should appeal as being of tangible advantage (in guiding their selection) to such a country. To the agriculturist, the dairyman or the fruit grower—large or small—the charges on the conveyance of his produce to its market are of the first importance. To the miner, the timber getter, or to the labourer in any other class of work or employment, cheap railway transport will stand forth as a necessary adjunct to cheap and comfortable living; while to the investor the importance of the facts to which his attention is drawn above will be at once apparent.

Leaving the detailed consideration of the above subjects, I will deal now with the statistics contained in the subjoined statement of operations during the past four years:—

	Year ending 30th June.			
	1896.	1897.	1898.	1899.
Miles open on date shown ...	588	970	992	1,355
Average miles worked during year	580	830	974	1,270
Capital cost, charged to Loan ...	£2,167,468	£3,526,461	£4,824,981	£6,073,058
Capital cost, charged to Revenue	£149,356	£208,016	£222,280	£354,312
Total Capital cost	£2,316,824	£3,734,477	£5,047,261	£6,427,370
Average cost per mile open ...	£3,995	£4,499	£5,088	£4,743

	Year ending 30th June.			
	1896.	1897.	1898.	1899.
Revenue—Gross earnings ...	£529,616	£915,483	£1,019,677	£1,004,620
Expenditure — Working expenses	£263,705	£577,655	£786,318	£712,329
Profit available to meet interest	£265,911	£337,828	£233,359	£292,291
Profit after payment of interest	£177,352	£83,698	£63,139	£85,034
Dividend per £100 of Loan Capital, which profit represents	£11 9s. 7d.	£9 0s. 10d.	£4 12s. 5d.	£4 11s.
Working Expenses per cent. of Revenue	49·79	63·09	77·11	70·91
Revenue per average mile worked	£913	£1,103	£1,047	£791
Working Expenses per average mile worked	£455	£696	£807	£561
Profit per average mile worked	£458	£407	£240	£230
Train mileage	1,541,750	2,537,192	3,613,874	3,257,871
Revenue per train mile ...	82·44d.	86·59d.	67·72d.	74·01d.
Working expenses per train mile	41·05d.	54·64d.	52·22d.	52·48d.
Profit per train mile	41·39d.	31·95d.	15·50d.	21·53d.
Number of passengers carried ...	1,679,816	3,607,486	5,669,444	5,872,200
Passenger receipts	£150,597	£303,124	£345,174	£312,685
Tonnage of goods carried ...	427,919	845,225	1,203,911	1,148,252
Goods receipts	£328,452	£467,667	£561,275	£582,315
Population of Colony	122,420	157,781	171,021	168,461
Railway revenue per head of population	£4 6s. 6d.	£5 16s.	£5 19s. 3d.	£5 19s. 3d.
Average number of journeys per head of population	13·81	22·86	33·15	34·86
Tonnage of goods carried per head of population	3·49 tons	5·36 tons	7·04 tons	6·82 tons
Population per mile of railway open	208	190	176	133
Capital cost per head of population	£18 18s. 6d.	£23 13s. 4d.	£29 11s. 10d.	£38 3s. 8d.
Number of locomotives ...	74	151	186	231
Number of passenger carriages	102	224	289	343
Number of goods wagons ...	2,360	3,485	4,478	4,558

The first few items of this statement will show how the increasing settlement and development of the country have required and obtained corresponding increases in Railway facilities. The capital cost, it may be mentioned, represents about 65 per cent. of the total National Debt of the Colony, and as no preliminary Parliamentary or other charges have been included, and no land has been debited, excepting where resumed from private owners, and in those cases only where improvements had been effected prior to the resumption, the Railways form a substantial asset in the property of the State.

The average cost per mile of construction, owing to many favourable conditions, is lower than in any of the other Australasian colonies. The gauge between the rails is three feet six inches.

The average cost per mile open, higher now by £748 per mile than at the 30th June, 1896, and notwithstanding that the average cost of additional lines has been considerably lower since that date than the general averages quoted, will furnish an illustration of the amount of money which has been necessary for improvements and additions to the stations and accommodation on the older portions, and even on the newer lines also, in many cases within a few months of their being taken over from the contractors, in order to deal with the ever rapidly increasing business. At the foot of the list also will be seen how the stock of engines, carriages, and wagons has been augmented, necessitating naturally a very large capital expenditure. Even now the number of wagons has been outgrown by the demands of the traffic, and is being therefore largely increased at the present time.

The Revenue and Expenditure figures also reflect various steps in the development of the country's resources, and they should be taken into consideration in conjunction with the mileage open, the number of new miles opened since the preceding year, and the remarks below regarding the rates charged and traffic carried.

As stated previously, the rates for conveyance of passengers or merchandise are not grounded on an undue profit-making basis, but are in many instances as low as is consistent with a payable charge. The surpluses produced and handed over to the National Exchequer, however, cannot but be regarded as satisfactory, and, while having every thought for the development of the national estate by the national means of communication and conveyance, yet it will probably be granted that this policy should not be ridden so far as to permit of a liability to any result but that of a fair margin of profit. The annual increases in train mileage have, in each year except in the last, been very heavy, but in 1899 a reduction was found possible without appreciable inconvenience to the general public, and effected a corresponding decrease in working expenses. Coming to the number of passengers carried, 1897 and 1898 each show an increase of over 2,000,000 as compared with the preceding 12 months, while 1899 has still a considerable increase over 1898. The tonnage carried during 1899 is nearly three times greater than it was in 1896, but the revenue derived is only just double. This result, and others shown in the statement (notably the increased percentage of working expenses to revenue), have been brought about by frequent reductions in fares and rates, the objects of which have been explained above. As an instance of this, a very marked increase appears in the percentage of the years subsequent to 1896. This has not been due to any difference in methods of working nor expenditure, but is attributable to the fact that, prior to June, 1896, rates for haulage over the goldfields lines were calculated with an addition of 50 per cent. over those of the older established lines. The reason for imposing this additional charge was that the permanency of the fields had not at that time been proved, and it was considered just that goods and passengers conveyed over what might eventually prove to have been only

temporary railways should pay such rates as would provide for the speedy redemption of the Loan money which had been spent on them. At the date mentioned, however, it could be seen that the permanent nature of the gold deposits was assured, and, as the impost was considered to have a repressing effect on the mining industry, it was removed, and the rates reduced to the ordinary level of the rest of the system. The natural result was the immediate and substantial increase in the ratio of expenditure to revenue. In 1898 again, further reductions in the tariff took place, and it will be seen that the average payment per ton in that year is the lowest during the four years under review, this average being 15s. 4d. in 1896, 11s. in 1897, 9s. 4d. in 1898, and 10s. 2d. in 1899.

The figures referring to the relations of the population of the Colony to railway receipts are of value as an index to the spending power and prosperity of the people, and also generally in connection with the figures which precede them.

When these statistics and returns on capital invested are taken into consideration with the low rates and fares prevailing—as shown earlier in this pamphlet—they will force upon the mind that a constantly watchful policy of management has been necessary to obtain such results, and this will more particularly be noticeable when one remembers that labour of all classes demands and obtains much higher wages, and that the expenditure for coal and water is far in excess of the rates paid in the countries of Europe, while practically all other railway stores and material (except sleepers and timber) have to be imported. A similarly sound policy of management also will ensure success in very many other business enterprises in West Australia, and there are a multitude of openings only waiting to be taken up to give handsome returns to their proprietors. To the investor in Western Australian Government securities the figures should afford satisfaction as an evidence of the stability of his investment.

The Locomotive, Carriage, and Wagon Workshops, which are situated at Fremantle, the principal port of the Colony, give employment to a large number of skilled mechanics and artisans, with the usual proportions of labourers and others. It is proposed to remove these shops to Midland Junction (about 24 miles inland from Fremantle), as the sea air has a certain deleterious effect upon the metal work, and also for the reason that the space available at the Port has been outgrown by the requirements of the work to be done, while the design upon which they were based when built in 1881 did not contemplate the developments of the present day. The room which they occupy in proximity to the lately completed river wharf will then be converted to the purpose of a traffic yard. At Albany, Geraldton, Kalgoorlie, Bunbury, and other outstations provision exists for the execution of minor repairs to engines and rolling stock.

The stations and station yards at Fremantle, Perth, and Midland Junction are lighted by electricity, arc lamps in the goods yards facilitating shunting operations during the night, in the

same way as is done in England. At Midland Junction are situated the Electrical Shops of the Department, where all work connected with electric telephones, signals, or lighting is performed, and the Permanent Way, Interlocking, and Signalling Workshops are also located there.

The Northern system of Government Railways, Geraldton to Cue (the principal centre of the Murchison goldfields), to Northampton and to Walkaway, is joined to the Southern system by a line 277 miles in length, between Midland Junction and Walkaway, constructed by the Midland Railway Company (of West Australia), a Joint Stock Corporation, of which the head office is in London. This Company's rates, fares, gauge and rolling stock are similar to those of the Government Railways. Their local headquarters and workshops are at Midland Junction. The line was built by the Company in 1887 on the "land grant" system, a concession of a certain number of miles of land on each side of the line being given to the Company free of cost in consideration of the benefits accruing from its construction. This principle has now, however, been abandoned, all lines demanded by public utility being constructed by the Government, usually by means of money raised by loan on the London market. There are also about 218 miles of private lines owned and worked by timber companies into the forests of their concessions. These are connected with the Government railway system, but are not controlled by the Department. They afford, however, considerable convenience to the companies and to their employees.

And the programme of the Colony in her railway progress is not at a standstill. The Government have declared their policy of extending railway communication to any locality where it may be required by circumstances, and where, after mature consideration, it is shown that such an extension will pay its way. They have evidenced this policy in the past, and are even now carrying it into execution by providing for lines from Menzies to Mount Leonora (about 80 miles), and from Northam to Goomalling (30 miles), and lines from Coolgardie to Norseman (108 miles) and from Coolgardie to Bonnie Vale (eight miles) have been recommended. The line of hills near Kalgoorlie, upon which are situated what are perhaps the richest group of gold mines in the world, are at present served by a short suburban line running their whole length (about six miles), but on one side only, and this it is proposed to convert into a circular line by the construction of a loop North of the hills to connect again with the existing line, thus forming a little suburban (double line) railway system similar in conception and design (except that it will be above ground) to the Inner Circle of the Metropolitan Company in London. These will all assist directly in the development of gold mining and its kindred industries. The agricultural interest is well served now by lines of railway constructed through fertile and well-watered districts, but an additional 30 miles is proposed in the Goomalling railway, which will tap a magnificent expanse of agricultural and pastoral country in the neighbourhood of Northam,

one of the chief agricultural centres of the Colony; and the intending colonist or investor may rest assured that his interests in regard to railway transport will always receive attention wherever there is a prospect of a railway paying its way in a fair and equitable manner. From the table given below, showing the dates of opening the various sections and extensions, some idea will be arrived at of the manner in which the resources of the Colony have, during the past few years, unfolded themselves, and have demanded correspondingly increased railway mileage. For convenience sake the principal industries served are also quoted, and, taken in conjunction with the map of the Colony included in this book, will furnish the reader with a knowledge of the localities in which these are carried on:—

Length.	Between	Opened.	Industries served and traffic carried, etc.
M. C.			
34 17	Geraldton and Northampton	July, 1879	Copper and lead mines in vicinity of Northampton, and agriculture along route.
19 63	Fremantle and Guildford ..	March, 1881	Metropolitan Suburban traffic, and distribution of goods imported at Fremantle.
21 11	Guildford and Chidlow's Well	March, 1884	Gradual extensions of the original trunk line inland from the port of Fremantle demanded by increasing settlement and cultivation in the Eastern Districts. A large portion of the Goldfields traffic passes over these sections, and, together with the goods carried for the population along the line, and from the Agricultural districts to the Capital, renders them the busiest of the system. This group is called the Eastern Railway.
1 69	Perth Racecourse Branch	Jan., 1885	
48 72	Chidlow's Well and York .	Jan., 1885	
20 46	York and Beverley	Aug., 1886	
5 73	Spencer's Brook and Northam	Oct., 1886	
14 34	Clackline and Newcastle	Jan., 1888	Branch lines serving the agricultural and fruit-growing industries carried on in their respective neighbourhoods.
14 33	York and Greenhills	Sept., 1898	
16 4	Bunbury and Boyanup ...	March, 1891	These lines form the South-Western system, and serve the fertile districts of that part. Agricultural and dairy produce, fruit, etc., are carried, and a very extensive timber traffic (jarrah, karri, tuart, etc.) is taken from the mills and forest lines at all points throughout these sections. Timber and coal are also derived from the Collie line at Brunswick Junction for conveyance to all parts of the railway system, and particularly to the goldfields and ports of Fremantle, Bunbury, and Busselton. A considerable traffic is also springing up in sympathy with the development of the Greenbushes tinfield and the newly discovered Donnybrook goldfield, and, in addition, Bunbury and Busselton as health resorts attract numerous passengers.
53 28	East Perth Junction and Pinjarra	May, 1893	
56 71	Pinjarra & Picton Junction	Aug., 1893	
9 58	Boyanup and Donnybrook ...	Nov., 1893	
27 78	Boyanup and Busselton ...	Dec., 1895	
42 26	Donnybrook and Bridgetown	Nov., 1898	
25 63	Brunswick Junction & Collie	July, 1898	Connects the Collie coal mines with the general railway system, and places a large tonnage of coal on the railways for distribution to the various centres, and to Bunbury and Fremantle for export
46	Canning Racecourse Branch...	Feb., 1896	Two short sidings to the stations adjoining the grand stands of the respective courses.

Length.	Between	Opened.	Industries served and traffic carried, etc.
M. C. 1 48	Bunbury Racecourse Branch	Nov., 1897	At the Canning Racecourse meetings are held at frequent intervals, and at Bunbury once a year.
170 1	Northam and Southern Cross	July, 1894	These sections were rendered necessary by the discovery of the famous Eastern gold-fields of Western Australia, firstly at Southern Cross (Golden Valley), then at Coolgardie, Kalgoorlie, Menzies, and various intermediate places. The traffic consists of timber, firewood, coal, fodder, and general merchandise required for working the mines, prospecting, and for the large population dependent thereon, with refractory gold-bearing ores for smelting at Fremantle, and sandalwood as return loading. A good deal of land has been taken up and cultivated between Northam and Hine's Hill since the opening of these lines.
138 20	Southern Cross and Kalgoorlie	Jan., 1897	
80 39	Kalgoorlie and Menzies ...	Feb., 1899	
9 11	Kalgoorlie, Boulder, and Lakeside	Nov., 1897	A suburban line, serving the mines of the Boulder group and the thick population surrounding them. Numerous sidings off this line go direct to the mine buildings, and both goods and passenger traffic are very heavy.
12 65	Kalgoorlie and Kanowna ...	June, 1898	A branch line, serving the mines and alluvial diggings at Kanowna (formerly White Feather).
243 0	Beverley and Albany	Dec., 1896	This line was constructed and worked by the W.A. Land Company, from whom it was purchased, together with the land concession held by the Company. It passes through good agricultural and pastoral country, from which a fair traffic is developing gradually. At Albany a large quantity of timber is shipped from the Denmark forests. Sandalwood also is found at various points along the route.
17 53	Geraldton and Walkaway ...	July, 1887	Built to connect the port of Geraldton with the Midland Company's line, and runs through rich wheat growing flats.
57 7	Mullewa Junction and Mullewa	Nov., 1894	These two sections connect Cue, the principal centre of the extensive Murchison gold-fields, with Geraldton and the rest of the system. The traffic consists mainly in meeting the requirements of the mines and mining population, which are numerous along the route and in the interior.
196 48	Mullewa and Cue	July, 1898	
11 71	Midland Junction and Lion Mill (Deviation)	July, 1896	This loop line was found necessary to avoid the heavy grades and sharp curves of the old line in passing over the Darling Range. It passes through some of the finest scenery on the system.
2 60	Fremantle to Owen's Anchorage	Oct., 1898	From the stock landing jetty and explosives magazines into the station yard at Fremantle. The traffic is confined to goods trains only—live stock, explosives, and ore and material for the Fremantle Smelting Works, which has a siding leading off the line.

Reference to the map will show also that of this vast territory of 1,000,000 square miles, a very small portion only has been developed or touched by railways, and that an enormous area awaits the arrival of population to subdue it to the advantage of mankind. The particulars given of the work of the railways, and the deductions which may be drawn from them of the general prosperity of the country, and of the facilities and opportunities afforded to the producer in any form—from any country, or of any nationality without distinction—taken in conjunction with the reflection that many thousands of acres of both mineral and agricultural lands in close proximity to existing lines of railway are still unoccupied, unprospected, and untraversed by man, will no doubt justify the conclusion that further prosperity can be the only result of additional population, and that the Colony of Western Australia does and will, for many years to come, welcome the enterprising settler and afford him—provided that he has sufficient capital at his command to give him a fair start, and a fair stock of energy and resourcefulness—every element and prospect of success and wealth. To Europeans of every nationality the same opportunities and privileges are granted as to natives of the Colony, or any other English speaking people. The railway industry is only one of the many forms of commercial enterprise carried on in the Colony, and the success which has attended it may be accepted as a specimen of the results which have crowned so many other undertakings. The heavy traffic will show the large quantities of goods which are carried, and the number of passengers who can and do afford to travel both on business and pleasure—in fact, as I have previously stated, the intelligent consideration of these facts and figures will furnish the mind with a fair idea of the advantages of the Colony of Western Australia as a place of residence for the pursuance of business, manufacturing, agricultural, mining, or other occupations allied thereto, or as a place for the investment of capital to enable these industries to be extended.

FREMANTLE HARBOUR WORKS.

General Description.

(*By C. Y. O'Connor, C.M.G., Engineer-in-Chief.*)

1. The Port of Fremantle, from its geographical position, must of necessity be the principal port of Western Australia, situated as it is within 12 miles of Perth, the capital city of the Colony.

2. Both of these important towns are built on the banks of the Swan River, but owing to the fact that the entrance to that river at Fremantle was, until recently, completely blocked by a rock bar, awash at low water, and with only two feet rise of tide, all vessels calling at the Port were compelled to either anchor in the open roadstead and discharge their cargoes into lighters, or lie alongside the unprotected ocean jetty, which was only possible in very fine weather.

Fremantle Harbor.

3. The necessity of providing better facilities for shipping for a long time engaged the attention of the Government of Western Australia, but nothing definite was done in this direction until the year 1891, when it was determined to convert the estuary of the River Swan into a harbour by the construction of sheltering moles in the ocean, and excavation of entrance channel through rock bar, and dredging and wharves, etc., within the estuary itself.

4. The moles to start from the North and South side of the estuary respectively, and to be carried out to such extent as might be necessary to shelter the entrance channel.

5. The entrance channel to be 30 feet deep, and 450 feet wide, blasted and dredged through the rock bar, which extended from water level at coast line to 30 feet below water about 4,500 feet out from coast line, and also extended 1,000 feet up river.

6. The inner basin to be about three-quarters of a mile in length and 800 feet in width, and 30 feet deep, with quays along both sides; the original depth of water on the average having been about 6 inches, allowing for the sandbanks above low water mark. (The width of basin has since been decided to be increased to 1,400 feet, with projecting jetties on North side.)

7. The scheme also included the reclamation of land for railway purposes on both sides of estuary, the area ultimately decided to be so reclaimed being about 80 acres.

8. These works were estimated to cost about £800,000, and to take about eight years to complete, and, Parliamentary authority having been obtained, they were commenced in November, 1892, and have been steadily proceeding since then, and are now rapidly approaching completion.

9. On the plan and section herewith the full lines show the works completed, and the colors represent work in progress.

Breakwaters.

10. The two breakwaters were first constructed, being built on the "Pierres Perdues" system. The Northern breakwater, which is on the side of the harbour from which all bad weather comes, was carried out to a distance of 3,450 feet, absorbing 575,277 cubic yards of stone, in blocks varying from 1 to 30 tons. It has a top width at the ocean end of 60 feet (exclusive of rounded head), and rail level 17 feet 9 inches above low water, with rough rubble parapet standing 13 feet above that. The side slopes on the ocean side are very flat, specially large stones being used in this portion of the work, which, since its completion, has been subjected to heavy gales for several years without any material damage having been done to it.

11. As the entrance channel is protected from the South by outlying islands, it was only necessary to carry out the Southern Mole for a length of 2,040 feet, absorbing 257,334 cubic yards of stone, in blocks of somewhat lesser size than in the North Mole.

12. The Northern breakwater has been constructed at an average cost of 42·6 pence per cubic yard, and the Southern breakwater at an average cost of 44·3 pence per cubic yard.

Blasting the Bar.

13. The blasting of the rock bar, preparatory to dredging it, was really the most important work of the whole scheme, as, on its being satisfactorily done, depended the success of the undertaking. In order that the rock might be sufficiently shattered to allow of its being removed by dredges, it was necessary to blast the whole of the area to be deepened, viz., about 54 acres. For this purpose trestle stages were erected, and from these stages holes 3 inches in diameter, and spaced 10 feet apart, were drilled in the rock by hand to a depth of 33 feet below low water. As each hole was completed it was charged, by means of a watertight tin tube, reaching from bottom of drilled hole to above water level, with gelignite and dynamite, and each row of holes so charged was exploded by means of time fuses. Owing to the proximity of the town of Fremantle not more than 50lbs. of dynamite could be fired at one time, and this restriction considerably impeded the progress of the work. Before each row of shots was fired the trestles were removed to the unblasted portion, and the operation thereafter repeated. 1,153,635 cubic yards have been blasted in this manner at an average cost of 34·03 pence per cubic yard. In addition to this, however, 247,058 cubic yards of rock were removed without blasting, which brings down the average for drilling and blasting to 28·03 pence per cubic yard of rock subsequently dredged.

Rock Dredging.

14. The work of dredging the blasted rock was carried on by means of bucket ladder dredges. Only two of these have been used, but for the last three years they have been working continuously night and day for six days per week.

15. The total amount of rock dredged to the 31st December, 1899, was 1,400,693 cubic yards, which includes the 247,058 cubic yards of soft rock already mentioned as having been dredged without being previously blasted.

16. Adding the cost of dredging, which averaged, for rock dredging, about 1s. 2d. per cubic yard, to the expenditure incurred in drilling and blasting, gives a total (approximately) of 3s. 6d. per cubic yard as the average cost of removing the rock. This includes the cost of explosives and all materials used.

Sand and Clay Dredging.

17. Inside the rock bar the material met with in the Inner Basin, which will have an area, when completed, of 109 acres, consisted chiefly of sand and clay, with a considerable amount of seaweed in places. Two suction dredges have been engaged removing this; 243,119 cubic yards of sand were pumped ashore, thus reclaiming 54 acres of land on the South side of the river, while the

balance of the material dredged to date, amounting to (approximately) 3,500,000 cubic yards, has been carried to sea, a distance of $2\frac{1}{2}$ miles each way, total journey five miles. About 2,500,000 yards of sand, clay, and seaweed have still to be dredged, but it is anticipated that this will all be removed during the present year.

18. The cost of dredging done to date in the Inner Basin, including the pumping of some of it into reclamation ground as already mentioned, has averaged about 7d. per cubic yard. It is anticipated that what remains to be done will be cheaper.

Wharves.

19. For the whole length of the South side of the Inner Basin a wharf has been constructed which, with the reclaimed ground, forms the present Railway Station Yard at Fremantle. The total length of this wharf is 4,980ft., of which 4,575ft. is at present available for shipping, the remainder being in various stages of completion. For 870ft. of the wharf there is a depth of 30ft. of water; for 980ft. there is 27ft. of water; for 1,110ft., 20ft. of water; and for the remaining 1,615ft. there is a depth of from 15ft. to 12ft. of water. The depth throughout the whole length of wharf will be 30ft. within the next few months.

20. Owing to the rapid development of the Goldfields there has been an enormous increase in the shipping trade of Fremantle during the last few years, which has necessitated more wharf accommodation being provided than was contemplated in the original scheme. Thus, to meet the urgent demands of coal and cattle traffic, a wharf 1,000 feet in length has been constructed on the inner side of the North Mole, where all coal ships and some cattle ships discharge their cargoes, and the coal is conveyed thence about $1\frac{1}{2}$ miles by rail to the coal depôt which has been formed on the North side of the harbour. A wharf for timber ships has also been built on the inner side of the South Mole for a length of 300 feet. This makes 1,300 feet of wharfage in addition to the 4,575 feet of wharfage already mentioned. There is, therefore, available at the present time 5,875 feet of wharfage.

21. On the North side of the harbour the work is not so far advanced. It is proposed to construct here five jetties, each being of sufficient size to accommodate two mail steamers. The first of these jetties is now approaching completion, and the basin has been dredged to full width and full depth for some distance to enable it to be utilised.

Further Extension of North Mole.

22. With a view of affording still further protection in bad weather for the large mail steamers that now frequent the Port, it has been decided to extend the North Mole a distance of 1,350 feet, and the work is now in hand, as will be seen by reference to the plan. The total length of this breakwater, as at present authorised, will therefore be 4,800 feet.

Graving Dock.

23. Parliamentary authority has also been obtained for the construction of a Graving Dock, which shall be capable of taking in any of the large steamers now trading to Australia. The position of the proposed dock is shown on the plan, and the work of construction will be commenced as soon as the dredging of that part of the harbour is sufficiently advanced.

Financial and other Advantages gained.

24. The advantages already gained by these works are very important and numerous, including amongst other things the use of the harbour by steamers of higher class and larger tonnage than could be induced to come to the roadstead previously; and there is also a very large pecuniary advantage in many ways, amongst others in the saving of cost of lighterage, which was necessary before the present harbour was constructed.

25. The cost of lighterage thus involved in 1896, deduced from Customs returns, is estimated to have been about £68,400, and, on the same basis, the lighterage during last year (1899) would have come to at least £87,000; and this alone is much more than double the interest which the Government have to pay on the cost of the works up to date (about £750,000), and is even more than double the interest which will have to be paid on the present estimated cost of the works (about £1,000,000), the works as actually being carried out being more extensive than originally estimated for.

COOLGARDIE WATER SUPPLY SCHEME.

For Supplying Water to the Principal Goldfields of Western Australia.

(By C. Y. O'Connor, C.M.G., Engineer-in-Chief.)

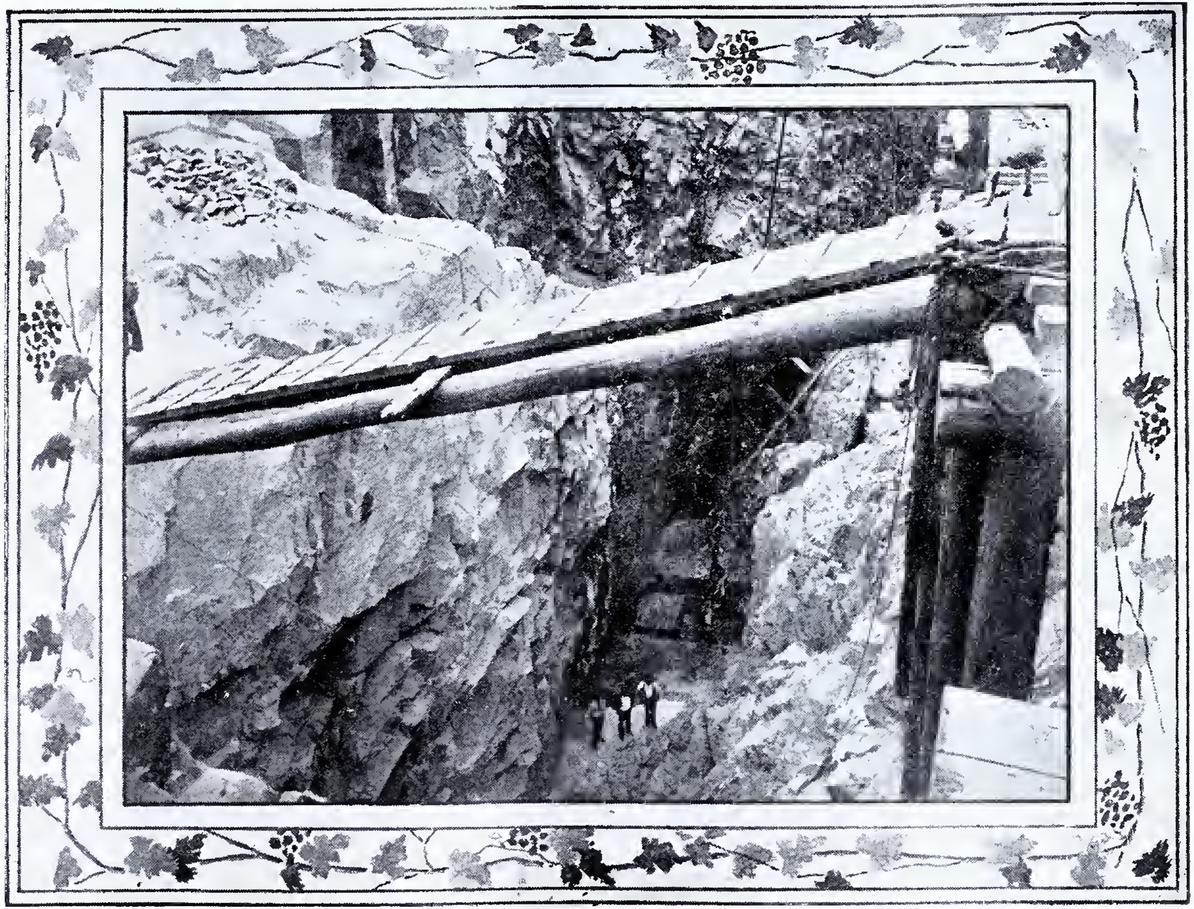
1. In the project known as "The Coolgardie Water Supply Scheme" it is proposed to deliver to the goldfields of Coolgardie, Kalgoorlie, and surrounding districts a supply of five (5) million gallons per diem of fresh water, to be pumped from a storage reservoir on the Helena River, about 23 miles from Perth and 325 miles from Coolgardie.

2. The works contemplated and now in course of construction consist of:—

(a.) Storage reservoir on the Helena River.
(b.) Pumping installations at eight stations.
(c.) Main conduit of steel pipes.
(d.) Receiving tanks, minor reservoirs, and service reservoirs.
(e.) Distributing pipes on goldfields.

Storage Reservoir.

3. As a result of gauging of the Helena River flow, it has been decided to construct a regulating reservoir capable of storing two years' supply.



Coolgardie Water Scheme. Excavations for Weir.

4. This is to be obtained by building a concrete weir with height of crest 100ft. above the river bed; and, as the foundation is in one place nearly 100ft. below the river bed, the total height of the weir from bottom of foundation to top of crest is thus, in one place, nearly 200ft. This, however, applies to a length of 15ft. only of the wall, the top length of which will be about 700ft.

5. The width, or thickness, at level of river bed will be 85ft., the rock walls of the excavations below that level being such that this width of 85ft. will be also the maximum width of the concrete structure.

6. The width near crest will be about 15ft., and the crest and lip of the weir are designed for a "curve of contact" to avert any leaping by the overflow during exceptional floods.

7. The waste-weir is to be formed on the main wall, and will provide for a free overflow 5ft. deep and 400ft. wide.

8. The usual accessories of valve tower, scour pipes, outlet pipes, gangway, etc., will be constructed.

9. The depth of water at full supply level, namely, from level of river bed to crest of weir, will be 100ft.

10. The lowest level from which water will be pumped is 20ft. above river bed, and the capacity of reservoir above that level will be 4,600 million gallons.

11. With the reservoir full, the water will extend up stream to a distance of 7½ miles from the weir.

12. The excavation for the foundation of the weir wall has been made, and all necessary trenching and chasing completed.

13. Cement slaking and storage sheds, stone-crushing plant, and concrete mixing machinery, together with general repairing workshops, have been erected, and the construction of the concrete weir has been commenced.

14. An electric lighting installation has also been set up, so that the work can proceed night and day, if considered necessary.

15. It is estimated that the weir will take about eighteen months from this date to complete.

Pumping Installations.

16. The bed of the Helena River at the weir site is 320ft. above sea level, and the lowest supply level from which water will be pumped is 340ft. The main part of Coolgardie townsite is about 1,400ft., and of Kalgoorlie (25 miles further eastward) about 1,230ft. above sea level, and the main distributing reservoir will be 1,585ft. above sea level. The total net lift to the main distributing reservoir is, therefore, about 1,245ft., and, adding to this the head due to frictional resistance in the pipe main (with a liberal margin for incrustation and allowance for maximum possible loss of head,

due to variation of water level at pumping stations and other contingencies), the total gross lift, including friction, is 2,632ft.

17. Another matter of importance is that of dividing the total lift amongst several sets of engines and pumps, variously located along the pipe line. The pipe main to Coolgardie being 325 miles in length, it is imperative that the thickness of the pipes be kept within economical limits; and, in order to achieve this without undue division of the pumping installations, and having regard to the irregularity of the profile, it is considered that eight pumping stations will give the best results, and arrangements have been made accordingly.

18. The first pumping installation will be located close to the main storage reservoir, and will consist of three sets of boilers, engines, and pumps—two sets to work and one to spare; and each set will be capable of pumping 2,800,000 imperial gallons per diem against a head, including friction, of 450ft. The second pumping station is located on the pipe line at a distance of about $1\frac{1}{2}$ miles from the first pumping station. The machinery at No. 2 station will be precisely similar to that at No. 1. and will raise the water to a high point on the Darling Ranges, from which it will gravitate (through pipes laid generally alongside the railway line) for a distance of about 75 miles to pumping station No. 3 (77 miles from station No. 2), the machinery of which will be precisely similar to that of Nos. 1 and 2. From station No. 3 the water will be pumped to station No. 4, which is 140 miles from the head works, and about $61\frac{1}{2}$ miles from station No. 3, the machinery at station No. 4 being similar to that of stations Nos. 1 to 3.

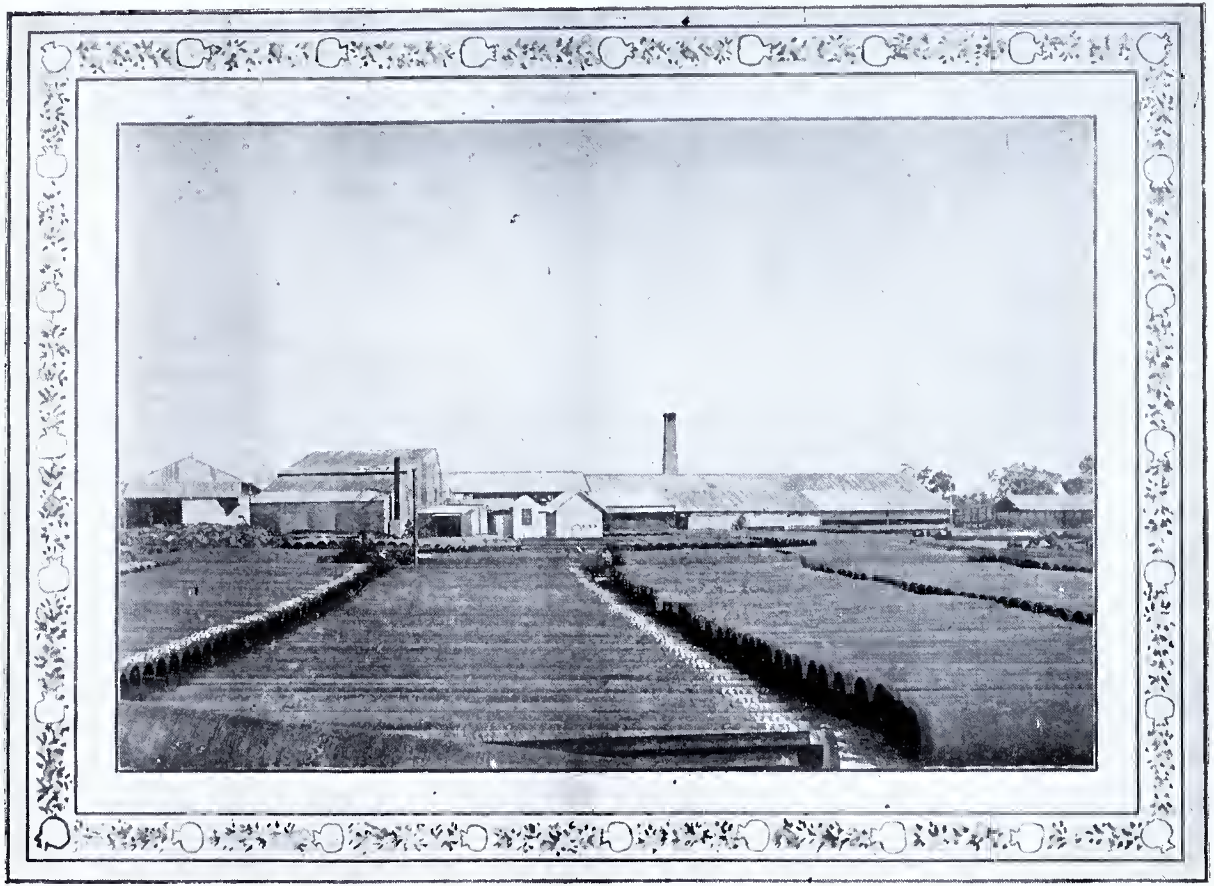
19. Stations 5 to 8 (inclusive) are located close to the railway, and at the following mileages on the pipe line:—No. 5, 171 miles; No. 6, 217 miles; No. 7, 248 miles; No. 8, 293 miles. At stations 5 to 8 (inclusive) the machinery will be similar throughout, but there will be only two sets of boilers, engines, and pumps (one to work and one to spare) at each station, and the total normal lift provided for at each is 225ft.; but with the further provision that, while each set of pumping engines will be capable of raising the full supply to a height of 225ft., it will also be capable of pumping past one station or reservoir, and on to the next station or reservoir, a reduced supply corresponding to the increased head.

20. Tenders for the supply of the pumping machinery have been invited from several prominent pump manufacturers in England, America, and the Continent of Europe, and many were received in response to the invitation.

21. The tenders are now under the consideration of the Government, and it is expected that a contract for the whole will be let very shortly.

Main Conduit.

22. The main conduit consists of steel pipes of Mephan Ferguson's Patent Locking Bar type. The internal diameter throughout is 30 inches, the minimum thickness $\frac{1}{4}$ of an inch, and the maximum



Coolgardie Water Scheme. The Pipe Works.

thickness $\frac{5}{16}$ of an inch. Generally the pipes will be laid in trenches, and connected by double socketed sleeves or thimbles with lead joints.

23. Two contracts, each for the supply of half the total quantity of pipes and joint rings required, have been let, one to Mr. Mephan Ferguson, of Falkirk, near Perth, Western Australia (the patentee of the pipe); and the other to Messrs. G. and C. Hoskins, of Midland Junction, near Guildford, Western Australia, at a combined cost of £1,025,124. Up to the present time (February, 1900) the construction of upwards of 20 miles of pipes has been completed, and their distribution along the pipe track has been commenced.

24. Orders for the valves required, and for all special joints required, will shortly be placed in England.

Receiving Tanks, Minor Reservoirs, etc.

25. At the pumping stations 2 to 8 (inclusive) receiving tanks will be constructed (excepting cases where suitable reservoirs already exist) of sufficient capacity to provide for irregularities in the pumping and for other contingencies.

26. *Minor Reservoirs.*—At several high points along the line regulating reservoirs will be constructed, with a capacity of from 1,000,000 to 12,000,000 gallons each, for which surveys, trial bores, and shafts have already been made.

27. *Service Reservoirs.*—These will be constructed on hills in the vicinity of Coolgardie and Kalgoorlie.

Distributing Pipes on Goldfields.

28. The principal of these consist of a steel main of about 21 inches in diameter from Coolgardie to Kalgoorlie, a distance of 25 miles.

General.

29. Generally, the pipe main will be adjacent to the railway line throughout, and the pumping arrangements are such that a reduced quantity of water can be pumped from station No. 5 past No. 6 to No. 7, also from No. 6 past No. 7 to No. 8, and from No. 7 past No. 8 to the main service reservoir.

30. With the pumping machinery arranged as above, and the requisite storage capacity provided for along the route and near the terminus, the contingency of cessation of pumping at any one station for a period of seven days is provided for.

31. The estimated cost of supplying the water is 3s. 6d. per 1,000 gallons, being about five per cent. of the present cost of condensed water on the goldfields which are to be supplied by the works above described.

32. The actual saving to the existing population may be stated as follows:—Assuming the population to be served by this water supply to be 42,000, and that their average consumption per

head (including some provision for condensed water for machinery and live stock) is five (5) gallons per day, as was ascertained some short time back by a careful reckoning of the people within the area which this water supply would command, the present consumption is 210,000 gallons per diem, and this, we are informed from the investigations already mentioned, costs the community £800 a day, which is equivalent to £292,000 per annum.

33. To supply an equal amount of water at the rate estimated in the water scheme would cost the population only, say, £36 per day or £14,000 per annum, an annual saving of considerably over a quarter of a million pounds sterling.

34. Or, to put the matter in another way, the community could readily use four times the quantity of water they do use, and would gladly do so if they could afford it, as the amount now used is barely sufficient to support life, leaving scarcely any margin for reasonable cleanliness; and if they get the water for 3s. 6d. per 1,000 gallons, they could use four times the quantity they now use at less than a fifth of the money they now pay for their present totally inadequate supply.

35. The great benefit to the Eastern goldfields generally that will accrue, on the completion of this water scheme, can thus readily be seen.

Summary of Principal Particulars.

Item.	Description.		Unit of Measure.	Amount.
1	Quantity of water required to be pumped per day of 24 hours		Gallons	5,600,000
2	Length of pipe main from storage reservoir to Coolgardie		Miles	325
3	Diameter of pipes to be laid (steel, locking-bar type)		Inches	30
4	Velocity of water per second		Feet	2·124
5	Net lift from storage reservoir to main distributing reservoir ...	1,245		
	Plus allowance for intermediate reservoirs	165	Feet	1,410
6	Head per mile allowed for friction		Feet	3·76
7	Total head allowed for friction		Feet	1,222
8	Estimated gross head		Feet	2,632
9	Weight of water to be raised per diem ...		Tons	25,000
10	Work per diem		1,000ft.-tons	65,800
11	Net effective power required		No. of H.P.	3,102
12	Power to be supplied—			
	P.H.P. of engines in work ...	3,712		
	Plus P.H.P. of engines in reserve	2,475	No. of H.P.	6,187

Exhibition Buildings, Coolgardie.

The Western Australian International Exhibition of 1899, Coolgardie.

Its Success and Benefits to the Colony.

(By H. Lawrence Read, J.P.)

Though to many the idea of holding an International Exhibition in Coolgardie—a place that had only become known to white people six years before—may have appeared presumptuous and objectless, there is ample evidence that the spirit and enterprise of those who originated and carried it through resulted in far-reaching effects, and have already borne good fruit in the Colony, to say nothing of the advertisement given to Western Australian productions throughout the civilised world.

Originally the members of the Coolgardie Mine Managers' Institute put the project before the public in the form of a proposal to hold an exhibition of mining and gold-saving appliances, or, as stated by them, "an exhibition, the arguments in favour of which rest, primarily, on the necessity of securing a more rapid and successful development of the Colony's mineral resources, by practical trials of ore-reducing and gold-saving machinery on the goldfields, under the practical working conditions that exist thereon."

This proposal was placed before the Right Hon. Sir John Forrest, Premier of the Colony, by whom it was approved and supported in a manner quite in keeping with the zeal ever displayed by him in furtherance of the interests of the Colony. At this time Coolgardie had only been discovered something like four and a-half years, yet in that short period a railway line had been constructed from Northam to Kalgoorlie, a distance of 316 miles (being 396 miles from the port of Fremantle), through sand-plains and waterless wastes, in order to afford every possible comfort to the newer settlers, and every facility to those engaged prospecting and developing the already world-famed mineral wealth of the goldfields. And it must be borne in mind that this was not 10 years after the granting of Responsible Government to Western Australia.

It was, therefore, but natural, when the original exhibition proposals were submitted to him, that the Premier should offer every reasonable encouragement and help to insure its success; and it was equally in keeping with his well-known progressive policy that he should favour a more comprehensive scheme, having for its object the fullest exposition of the Colony's resources.

For in Western Australia peculiar and difficult circumstances had arisen from the wonderful gold discoveries, circumstances which were perhaps unique in the world's history.

With a limited and settled population, and no important outside markets available, there was little or nothing to stimulate increased production from the cultivable lands which abounded in the Colony. But following the discovery of Bayley's came a heavy inrush of population, and immediately there was set up a demand for what the Colony is easily capable of producing under largely increased land cultivation, but which it could scarcely be expected to produce until a few years after a general realisation of the future prospects on the part of the older settlers, who could scarcely be expected to immediately quadruple their supplies, even after becoming convinced of the necessity of so doing.

Here was a position on which, in view of the facts, a dispassionate onlooker would inevitably be forced to one conclusion, premising that the object to be gained was the Colony's advancement.

And this was the conclusion arrived at and expressed by Sir John Forrest, and in pursuance of the policy which it dictated he has resolutely set his hand to the encouragement of production up to the standard of the Colony's requirements, under the belief that in the course of a very short period our farmers, fruit-growers, and other producers, by virtue of their proximity, and of less necessary handling of products, will be able to send their supplies forward to the fields at a much cheaper rate than the Eastern railways.

The readiness with which the Government supported the more comprehensive scheme is therefore at once understandable and appreciable, and already the results are sufficiently noticeable to justify the expenditure that was incurred by the undertaking. Fruit (a daily necessity), which was for a long time absolutely unobtainable, and subsequently brought very high prices, has cheapened on the goldfields considerably since the growers were induced to visit the Exhibition, and were thereby brought to realise the immense markets open to their direct supplies; and the same remark applies to many other necessaries of life produced in the Colony. But more important still, the same cause has operated towards increased cultivation, and there has been a large encroachment on the formerly untilled lands—an encroachment that is steadily continuing. Another object in having the scope of the Exhibition extended was to illustrate the wealth of the Colony in products for which the internal markets did not set up a sufficient demand; in fact, in which the supplies can become practically unlimited, such as timbers, wines, dried fruits, preserves, olives, vegetable oils, honey, etc., etc. Those who visited the Exhibition will bear testimony to the magnificent and extensive display made in these articles.

The Exhibition was opened on the 21st March, 1899, by His Excellency the Governor, Lieutenant-Colonel Sir Gerard Smith, K.C.M.G., assisted by the Right Hon. Sir John Forrest, P.C., K.C.M.G., Premier of Western Australia, and the members of his Ministry, and among the visitors were the officers of the Australian Squadron, and Captain Cowarde and the officers of H.I.M. Austrian s.s. "Saida."

The closing ceremony took place on the 1st July following, and during the period of its opening the attendance exceeded 75,000. The total number of exhibits was 18,739, and, as had been desired, these were thoroughly varied and comprehensive in character, and comprised splendid illustrations of Western Australian productions.

The President of the Exhibition was A. E. Morgans, Esq. M.L.A. for Coolgardie, and the Chairman of Foreign Relations and Administration was H. Lawrence Read, Esq., J.P., both of whom rendered yeomen service, and to these gentlemen, in conjunction with the Premier, is due in great part the signal success of the undertaking.

Mineral Court.—The organisation of a Mineral Court was chiefly due to Mr. H. Lawrence Read, and the special collection contained therein, approximately valued at £140,000, must have afforded that gentleman the satisfaction that he had undoubtedly earned. It was unquestionably the finest collection of its kind ever got together, and was the feature *par excellence* of the Western Australian Exhibition.

It was due to that fact that Western Australia was so unanimous in securing representation at the Paris Exposition in 1900, and those who have the favoured opportunity of inspecting the mineral display thereat will realise the value of the Exhibition so recently held in Coolgardie. There is probably no country in the world that can vie with Western Australia in mineral wealth, and it is pleasing to know that the efforts of those who promulgated the idea of the International Exhibition of 1899 have resulted in so fine a display of the same being made in the great Paris Exposition. The known mineral products of the Colony include gold, silver, copper, tin, coal, and diamonds.

Agricultural Court.—Herein was also a magnificent display, which will be partly, but obviously not wholly, represented at Paris. There will, however, be a very fair representation of non-perishable products.

Timber Court.—This was second only to the Mineral Court, and the chief exhibits, comprising specimens, dressed and undressed, of jarrah, karri, tuart, wandoo (a beautiful ornamental timber), blackbutt, Morrell gum, York gum, sandalwood, and about 20 other varieties of useful and ornamental timbers, have followed on to Paris.

Fruit.—The Colony is specially favourable for the cultivation of fruit of nearly every kind, and even on the goldfields attention is being turned in this direction.

The display at the Western Australian Exhibition was made specially attractive by reason of fresh supplies coming forward regularly. There is a prospect of big trade in the future in dried and preserved fruits.

Wines.—These are destined to rank very highly among those of the Australian Colonies, and of the Continent. The climatic

conditions are essentially favourable to the cultivation of the best kinds of grapes. To experts in the cultivation of the fruit, and its manufacture into wine, Western Australia offers a great inducement, especially in view of the liberal regulations for the leasing and purchase of areas of land.

Taken altogether, the display at the Western Australian Exhibition was of a high character, and led to the representation of the Cinderella Colony at the Paris Exposition of 1900.

From a West Australian standpoint it was influentially a signal success, and has achieved the objects set out by the Commissioners which were: "to test the suitability of machines to local requirements; to promote and foster Industry, Science, and Art; to encourage invention; and to stimulate Commerce."

In conclusion, it is a fact, and more than creditable, but wonderful, that a Colony of 170,000 inhabitants placed before the World an International Exhibition on a spot that five years before was a desert, but is now a flourishing centre of one of the great goldfields of the world, as the town of Coolgardie is. This Exhibition sent forward to all quarters of the globe 150,000 circulars dealing with correct statistical and other facts as to the Colony's boundless resources. That 78,000 to 80,000 people visited that Exhibition: also that the Exhibition was not, as many another exhibition has been, a financial failure, but a financial success. The money expended was all but paid for by receipts for space and gate money, the balance remains to the credit of the Government in valuable land and buildings.

The land and buildings are to be utilised for the purpose of a permanent agricultural exhibition and storage, so that the farmers of the vast agricultural areas of the Colony may place at a very reasonable rate their produce for sale to the large and increasing population of the Goldfields. The Western Australian International Exhibition has had the great success of placing the vast Goldfields population in touch with the vast agricultural areas and its inhabitants.

It can be noted by the world, with praise, that all is due to a great and far-seeing Premier (Sir John Forrest), his Government, and advisers, as a fact, that the Colony of Western Australia held a successful International Exhibition in its own land, and in the following year it sends to the world's great Exhibition at Paris an exhibit of mineral wealth such as, at the Coolgardie Exhibition, astonished the world's experts, on seeing its wealth and diversity; so will it again astonish the world's experts, scientific and mining, at Paris. I predict that that exhibit will be the greatest mineral collection that has ever been seen. This Colony is the only one of the Australian Colonies that has exhibited in Paris, which is a fact worthy of note and praise to Western Australia; and this mineral exhibit is the outcome of the Western Australian Exhibition at Coolgardie in 1899.

Agriculture has been represented at Paris, as at Coolgardie. It may truthfully be said that the Western Australian Mining and Industrial Exhibition at Coolgardie in 1899, in addition to showing the goldfields the vast agricultural resources to the Colony's inhabitants, has shown them to the world.

There are countless acres of soil waiting to be tilled for fruit-growing, olive culture, wines of many sorts and qualities, wheat and hay; one can say truthfully that but one thing is wanting in this land of milk and honey and balmy skies—it is population. Its timber forests, and the vast industries to be formed therefrom, were shown to a great extent at Coolgardie, as they will be at Paris.

For all this pluck, enterprise, and energy, the Colony and its inhabitants have to thank the man who has steered its successful course during nine long years: that man is the Premier, Sir John Forrest, and his Government. Under him and his Government, people of every and any nationality will find a Government that desires to help the poor as well as the rich; the Colony gives to all a true welcome, where happy homes can be built, and a great nation is fast arising; peace and health will meet you when stepping ashore at Fremantle, which is the Brindisi of Australia. I feel safe in saying that the Western Australian International Mining and Industrial Exhibition had a very great deal to do with the recent success of this great Colony in showing its boundless resources at the Coolgardie Exhibition, and, after the Paris Exhibition, to millions of the inhabitants of the globe. The portal gate of Australia is open to all; we can but wish its great success may continue, as it shall, there being nothing to mar its rarely clouded skies and balmy air, giving its open door to all, with it a welcome of peaceful, happy homes, in a land that is bounteous and profitable to all who desire to enter, be it with little capital or great.

Those responsible for the Coolgardie Exhibition are proud of the work so successfully carried to an issue at the Western Australian Mining and Industrial Exhibition, held at Coolgardie, Western Australia, in 1899.

The Spanish Benedictine Mission of New Norcia, W.A.

(*By J. P. Perrin.*)

The Mission of New Norcia, situated at a distance of some 84 miles North of Perth, is one of the chief features in Western Australia, or, perhaps, in the whole Continent, if indeed it may not be reckoned as of universal interest. It is there that final proof has been given that the Australian black is not, as has been charged against him, a being approaching in his want of intellect to the standing of the lower animals, but that he is capable of high intellectual development, and possessed of mental powers that may fit him to take a place in advanced civilization. The position, secular as well as religious, may be aptly summed up in the words of Governor Sir Frederick Broome, who, writing a few years ago of the impressions formed by him on a personal visit to the Mission, speaks as follows:—"I have known a full-blooded, low type savage go out from this noble Mission into civilized life, not only a good Christian, but an expert telegraphist."

The foundation of New Norcia was indirectly due to the suppression of the religious houses in Spain, and more particularly to that of the Benedictine Monastery of St. Martin of Compostella, in which Dom Serra and Dom Salvado, the founders of the Mission, were monks. These monks, on the suppression of their monastery, repaired to that of La Cava, near Salerno, in Italy. There they conceived a desire of going on a foreign mission, and, receiving an invitation from Dr. Brady, the Roman Catholic Bishop of Perth, who heard of them in Rome, they accepted it.

In February, 1846, the missionaries set out from Perth in search of a fit place in which to begin their work among the blacks. Their first experiences were of extreme hardship, as they depended on their own hands to provide them with a shelter in the bush, and their food was a little rice, to which they were obliged to add the larder of the blacks—lizards and insects of certain kinds. A concert given in Perth by Dom Salvado, who had returned there, ragged and labour-worn, to seek for aid, and who thus turned his powers as an accomplished musician to good account, provided them with means to purchase a bullock dray and team and a stock of provisions. They obtained also a grant from the Government of 40 acres on the Moore River. The lands of the mission now contain 20,000 acres held in fee simple, and some 300,000 acres leasehold, for which a rent of £1,000 a year is paid to Government. The monastery, whose foundations were laid on 1st March, 1847, with its surroundings of 16 square miles of territory, was made by Pope Pius IX. in March, 1867, an abbey *nullius*, exempted from Diocesan episcopal jurisdiction and erected a distinct Vicariate Apostolic.

Of the work done by the Mission it is impossible to speak too highly. The case is one in which literally the wilderness has been made to blossom like a garden; and, to crown these results, they have been obtained by the labour of those tribes to whom labour had been unknown, and who were supposed incapable of acquiring its habit. The difficulty of the task accomplished may be estimated by the many efforts made elsewhere to perform such a work of civilisation, but which ended only in failure. A broad expanse of land has been made fertile for the production of cereals. Gardening has been carried on very extensively and with marked success. The tobacco plant has been cultivated, and, among the industries, snuff-making is one of the most successful. The article manufactured is pronounced by judges to be unexcelled.

Wine-making has also been carried to great perfection, and olive oil of excellent quality is produced. Pastoral pursuits are likewise conducted on an extensive scale. There are large flocks of sheep and herds of cattle, and horse-breeding is a branch of which the Brother in charge is legitimately proud. At the recent Agricultural and Pastoral Show at Guildford a first prize for a draught horse was won. The progressive spirit of the Mission was also manifested by the purchase at the same show of mares for the improvement of the stock.

But once more to quote from Governor Broome:—"Here (he writes) you may see a mediæval monastery, with its religious and laborious life in chapel and in field. Wheat, grapes, olives, figs, and all manner of produce are cultivated on the extensive farms. Australian natives not only sing in church, or study in school, but are engaged side by side with the monks in agriculture and various industries, besides playing the violin and other instruments in the Mission band, and cricket in the Mission eleven."

The staff of the Mission at present consists of the Right Rev. Dr. Salvado, Bishop of Port Victoria, Abbot Nullius; Very Rev. Father Dominguez, Abbot-Coadjutor and Prior; Very Rev. Father Bertram, V.G.; Rev. Father Martinez, Acting P. Priest; Rev. Father Coll, Assistant. There are also 43 brothers. The aborigines residing at the Mission and provided for there in every respect number over 140. There are two schools—one for boys and one for girls.

The Beagle Bay Mission.

(By J. M. Drew.)

One of the aims of the Roman Catholic Church in Western Australia has been to bring the blessings of Christianity within reach of the aboriginal races of the country, and it is pleasing to be able to record that the effort has been attended with a measure of success far exceeding the results achieved in a similar direction in other portions of the Australian continent. Indeed, the outcome of the self-sacrificing and, in many instances, heroic endeavours of Catholic missionaries to evangelise and improve the moral condition of the black tribes of the province, has been such as to excite the wonder of those who know the aboriginal only in his semi-civilised state, after he has successfully mastered all the grosser vices of his white brother. The blackfellow, as we see him in our cities, is a most debased specimen of the human race. He is lazy, he is improvident, he is filthy, he is drunken, and he is vile. He has no thought for the morrow, he has no ambitions, he has not the remotest sense of honour or of principle—in short, he is as low a form of humanity as it is possible to conceive. Hence it is that we who daily meet the degenerate aborigines of our towns may well give way to astonishment when indisputable evidence is afforded us of the possibility of directing the faculties of a race, apparently so degraded, to a useful and more purposeful destiny.

One striking proof has been furnished by the New Norcia Mission of Western Australia that the aborigines of this Colony are not beyond the pale of civilising and christianising influences. That well-known mission, founded over 50 years ago by Spanish monks of the Benedictine Order, and still enjoying a vigorous existence, supplies ample evidence that the blackfellow may, in good hands, become an educated Christian. But yet another example is already forthcoming as to what may be achieved by the patience and zeal of religious men in lifting the wretched aborigines from the depths of paganism. It is to be found in the Beagle Bay Mission, established 10 years ago in the North-West of the Colony by French priests of the order of La Trappe; and it is of this mission that the writer now proposes to speak.

The first steps in the foundation of the mission were taken by Abbot Ambrose, in June 1890, when the good Trappist, with others of his order, set out from Beagle Bay to discover a suitable site for the scene of his projected work. The spot selected was seven miles from the port, and it was named "The Holy House of the Sacred Heart." A few months later His Lordship Bishop Gibney of Perth, in whose diocese the district of Beagle Bay was then included, purchased a large station, with all its appliances, situated a little to the North of the land allotted for the natives, and very generously presented it as a gift to the Trappists. This was the initial stage in the commendable work which had been gallantly undertaken.

The aborigines in the vicinity of Beagle Bay were, at this time, in a condition of absolute savagery. Yet it would seem that that fact rendered them more amenable to religious enlightenment than would have been possible had they been contaminated by contact with the ordinary forms of civilisation. Physically they were a singularly fine race of men; but they possessed more admirable attributes. They were noble and high-spirited, and though in their natural state wild and savage, yet in the hands of the tactful Fathers they proved gentle and obedient. The Trappists moved about among these barbarians unarmed and practically at their mercy. But never was the slightest attempt made to molest them—a circumstance which receives especial emphasis from the admitted fact that outside the range of the Fathers' sphere of operations murders of white men were not of infrequent occurrence.

It is true that on the first arrival of the missionaries the aborigines betrayed some indications of distrust and hostility. Approaching the new-comers with their usual weapons of war—the deadly barbed spear, the treacherous boomerang, and the murderous-looking dowak—they exhibited a disposition to forcibly resist the intruders. When they realised, however, as they soon did realise, that the strangers were on an errand of peace, that the commissariat of the little band was not lined with revolvers and rifles, suspicion gave way to confidence, and the savages, laying down their arms, offered the party many genuine tokens of friendship. From that time up to the present there has been no breach of the good feeling cemented in so simple a way.

To mention briefly the manners and customs of the blacks of Beagle Bay, prior to the advent of the missionaries, will not here be out of place. They gained a subsistence by fishing and hunting, the sea and the woods furnishing them abundantly with food. They roamed about almost naked, and, in summer and winter alike, slept in the open or under trees without clothing of any kind, only taking advantage at night of the warmth which a burning log would give. Many of their practices were of a most barbarian character; to others there could be but little objection on sentimental grounds.

The dress of the men in their wild state was peculiar. The hair was allowed to grow long. In some instances a band was fastened around the head, and the hair combed up over the band so as to form protection to the neck from the sun. In another case, the hair was drawn backwards and wound over a lump of paper-bark, which made a projection resembling a squirrel's tail. As a means of ornamentation, little tufts of cockatoos' feathers were twisted into the ends of the moustache and made to stand out stiffly, while a thin piece of bone, about nine inches long, was worn in the nose, the nasal septum having been pierced to admit it. The two central teeth were extracted. Painting and feathering the body, and the mutilation of the breasts, arms, and legs by scars, were resorted to for the purposes of adornment. Around one of the arms, the natives wore a band on which was generally fastened on an oval piece of oyster

shell. This indicated that the wearer had passed one of the stages to manhood. Around the waist of warriors was fastened another band, from which depended a carved oyster shell before and behind. Sometimes a piece of fur took the place of the oyster shell. A man to attain the rank of a warrior had to pass through several stages. Then he was painted all over the body with a red substance. A fighter who had been "painted" achieved a distinction among his tribe something akin to that enjoyed by our own Lord Roberts, and if he died he would not be buried, like his less illustrious brothers, under the earth, but his remains would be placed on a platform erected upon one of the trees of the forests. The carriage of these fighting men was very erect and so full of dignity that one could not help being struck by their kingly appearance as they marched, in all the panoply of war, through their native wilds.

Such were the savages among whom Abbot Ambrose and his devoted followers were called upon to labour. The spiritual care of these aborigines was, of course, the primary concern of the Trappists. To this end, the first work of the Fathers was to master the strange language of the tribe. Having accomplished so much, the task of assisting the blacks to grasp the principles of Christianity was a comparatively easy one. The catechism and prayers were taught in the native tongue, so that even the most untutored denizen of the ranges out back could comprehend their import. Thus the wild blackfellow of Beagle Bay recited "The Lord's Prayer," not in English as we recite it, but in the following peculiar words, the meaning of which was perfectly clear to his mind:—

Jérada ibaldiérada kalpañ kourwol minendier
Our Father of us up in heaven thou art who

Gnilaol wotch ioñgoretch dien
respecting
Thy name fearing let them be of it.
venerating

Cioye ualandie mpakañda tiaman
Thou master, thou, possess all

Malbeune ioñgheretch dié iénik bourok,
Obedient let them be of thee here on earth,

penelk malbeune ierédien dié kalpañ kourwol:
like obedient they are of thee up in heaven.

Wanao panañgar iërada mai dierada panañgar
food
Give to-day our inanimate of us of to-day.

Migandia reb armogoren dier
Forget
Forgive bad that we make

penelk argandieo reb ierénen dier dierada
as we forgive bad that they make to us.

Are milémanñgada ierada iongorvvolwolenk
Do not abandon us when they will coax

ierada rebetch. Reb wanamor, are
us for bad. Bad put away not

dar ilar dierada. Amen.
it come to us. Amen.

The labours of the missionaries have continued on the same happy lines on which they were begun. The natives regularly attend mass and devotion. After receiving a thorough religious instruction, the adults are baptised; as a rule, the children are christened as soon as they are placed under the control of the Trappists. Those who have been made Christians are admitted to all the spiritual privileges, of which they prove themselves worthy. They receive the sacraments in life, and, in death, a burial in accordance with the ritual of the Church. The aborigines invariably approach the sacraments with sincere fervour, and show a deep religious faith. Often the edifying spectacle is witnessed of a marriage before the altar between two of these erstwhile savages, who had probably been cannibals in the earlier portion of their lives. Discipline is insisted upon and strictly observed. The Christians who are married live on the station in houses which they have built for themselves; the single sleep in dormitories set apart for the purpose. Those in preparation for the reception of baptism camp about half a-mile from the mission. The camp is divided, in accordance with the natives' own rigorously moral code, into three sections—the middle section for the married, one side for the boys and single men, the other for the girls and young women. Under religious training the aborigines are required to, and readily do, give up and absent themselves from attendance at tribal ceremonies not in harmony with the spirit of the Church. Such of these customs as are regarded as innocent are, however, permitted.

But, although special attention is given to the religious instruction of the natives, their secular education is not by any means neglected. The children are taught to read and write; the adults receive a training in various handicrafts. Some become gardeners, others good boatmen and adepts in pearl-shell fishery; more learn the management and care of stock, while all are proficient in the use of ordinary tools. The result is that the station property has become gradually enhanced in value through the skill and willing toil of the coloured workmen. In spite of all this, however, the mission, as can be readily understood, is not self-supporting, and the Trappists are looking forward with confidence to a liberal measure of financial help from the Aborigines Department, now under the direct control of the Government, to enable them to achieve the degree of success which can only be obtained with heavy pecuniary outlay.

The agricultural capabilities of the station can best be shown by quoting in full a letter from the Right Rev. Dr. Kelly to the Agricultural Department of Western Australia. The Beagle Bay mission is now under the ecclesiastical jurisdiction of Bishop Kelly, who is well acquainted with the district, having spent some months there. His Lordship reported as follows:—

"Geraldton, January 1, 1900.

"DEAR SIR,—Having, at your request, applied for information as to the progress made in agricultural matters at the Trappist Mission, Beagle Bay, I have great pleasure in putting before you the result of my inquiries.

"1. As to the precise area under cultivation I have no information. It is divided as follows:—(*a.*) Six banana plantations, containing about 7,000 trees. (*b.*) A plantation of date palms, containing some 200 trees. (*c.*) A plantation of cocoanuts, containing about 60 trees. (*d.*) An acclimatisation garden, in which experiments have been made in growing pineapples, tamarinds, pawpaws, manioc, taro, tropical oranges, etc. (*e.*) A large vegetable garden, well stocked with a great variety of vegetables. (*f.*) A small patch of rice and another of sorghum.

"2. The following are reported as thriving well:—(*a.*) Melons of all kinds, pumpkins, sweet potatoes, cabbages, turnips, and all the ordinary vegetables; cocoanuts, pawpaws, manioc, taro, bananas, tobacco. (*b.*) Fairly well: Pineapples, sugar cane, dates, figs, tamarinds. (*c.*) Not thriving: Grapes have hitherto done well, but this year they seem to be in a far from healthy condition. The crop ripens in September. Rice seems to be injuriously affected by the fall of temperature which accompanies the rains."

The mission is at present under the charge of the Rev. Alphonse Kenny Tacheon, a French priest who assisted the Very Rev. Abbot Ambrose Janny in its foundation, the latter being now on a visit to Europe. The staff consists of eight priests, one seminarist preparing for Holy Orders, and 10 lay Brothers. The priests' names are, besides Abbot Ambrose and Father Alphonse, the Revs. Antoine, Francois, Placide, Jean Maria, Nicolas Emo, and Thomas Manillas. Apart from the chief establishment at Beagle Bay, there is a mission station at Broome under the charge of the Rev. Nicolas Emo, who has built a church there for the accommodation of the Catholic population—chiefly Manila men—and opened a school in which aboriginal children are taught. Also at Disaster Bay, 50 miles off, on the coast of King's Sound, another mission station has been commenced under the care of the Rev. J. M. Janny. At Beagle Bay, on July 28th, 1899, there were 67 aboriginal children nourished and instructed; 38 old natives cared for; 189 Christian blacks; and 100 pagans and catechumens. In all three centres of missionary endeavour the Trappist Fathers last year baptised 60 aborigines, celebrated nine marriages, and admitted 35 to their first communion. The object of the visit of Abbot Ambrose to Europe is to procure nuns, who will take charge of the native women and female children.

The Mission is now within the newly-created and extensive diocese of Geraldton, of which the Right Rev. W. B. Kelly is the Bishop. His Lordship, as has been already stated, is practically acquainted with the Beagle Bay district. He, moreover, takes a keen interest in the welfare of the natives, and is resolved to help on the work of the Trappists to the full extent of his power. Under such auspicious conditions there is little room for doubt that the Beagle Bay Mission will, in course of time, be a great civilising agency among the barbarians of the North-West of the Colony, and, by its good deeds, write its name in golden letters on the pages of Western Australian history.

Fremantle Lighthouse.

FREMANTLE,

THE CHIEF PORT OF WESTERN AUSTRALIA.

(*By A. J. Diamond.*)

The town and port of Fremantle is situated at the mouth o the Swan River, on the Western coast of the Continent, in latitude 32° 03′, longitude 115° 45′, and is looked upon as the coming Brindisi of Australia. Its unique geographical position, in relation to Europe on one side and the Eastern colonies on the other, justifies the title, and the magnificent harbour works in course of completion by the Government further emphasise it. Lying as it does in the direct track of all but one of the great steamship lines (the British-India) coming through the Suez Canal to Australia, it will shortly become the first port of call and the last of departure for their fleets. It is about four (4) days' steaming nearer to Europe than is Adelaide, and about eight (8) days' nearer than is Sydney. It is the principal coastal terminus of the railway system of the Colony, being distant only 363 miles from Coolgardie, and 387 from Kalgoorlie, the two great mining centres: while the projected extension of the rails to Port Augusta in South Australia, joining the systems of the two colonies, will bring Fremantle within two days' journey of Adelaide, and thus reduce the time of transit of mails and passengers between London and the Eastern colonies by fully two days.

At the present time a passenger arriving at Fremantle by sea can entrain daily for any station on the railway system of the Colony. Perth, the capital city, is situated 12 miles inland, on the River Swan, the river scenery between the two towns being very beautiful. The train services are frequent, and the drive by the road discloses some charming bush scenery.

The town is a bustling one, and its large and increasing shipping trade is rapidly pushing it into the front rank as one of the busiest ports in Australasia. The climate is almost perfect, being for the greater part of the year equal to the French and Italian Riviera. Passengers arriving at the port after a long sea voyage are able to purchase the most delicious fruits in shops within a few hundred yards of the wharf and grown in the neighbourhood of Perth and Fremantle. At the time of writing, table grapes are obtainable in Fremantle at 6d. per lb., of a quality and flavour which could not be purchased in Covent Garden, London, or the Halles Centrales, in Paris, at ten times the price; while the display of peaches, nectarines, melons, apples, pears, figs, and plums is superb. In the season, oranges of the very finest flavour and size are procurable.

As far as the early records can be relied on, it would appear that the locality of the town was first visited by Europeans in the

persons of Commander Vlaming and the crew of the Dutch vessel "Gielvink," in the year 1697, who discovered and named the Swan River in that year. It was visited afterwards at long intervals by navigators of various nationalities, and was finally taken possession of, on behalf of the United Kingdom, by Captain Stirling, of H.M.S. "Success," in 1827, who returned from Sydney two years later and started a settlement on the Swan River. Meanwhile Captain Fremantle, of H.M.S. "Challenger," had visited the site of the town, which was afterwards named after that officer. A rocky bar at the mouth of the Swan River and numerous sand-banks inside made navigation, except for small boats, an impossibility, and consequently the so-called Harbour of Fremantle until May, 1897, consisted of an open roadstead, partially protected by some outlying reefs and islands, while the wharfage accommodation consisted of a sea jetty of the most modest dimensions, which, however, was gradually added to until it reached the length of 3,295ft.

Sea communication with the Eastern colonies and the outer world was carried on for many years by means of a few sailing vessels, whose visits were few and far between, and it was not until 1882 that Fremantle enjoyed direct steam communication with her Eastern neighbours, while at the time of writing there are six lines of steamers engaged in the intercolonial trade ; a regular service of four steamers trading with Singapore, while London is brought into touch by the regular calls of the great cargo-carrying lines of steamers of the Gulf, Port, Federal, Houlders, and West Australian Shipping Association lines, and the subsidised mail-carrying lines are represented by the North German Lloyd Company, whose steamships call every four weeks, outwards and homewards.

In heavy weather, such as a North-West gale, it was, of course, impossible to embark or discharge passengers or cargoes at the jetty, and consequently the necessity of a haven of safety was for many years advocated. When the great English authority on Harbour Works, the late Sir John Coode, visited Australia in 1886, he was engaged to report on the subject, but it was not until the advent of Responsible Government in 1890, under the premiership of Sir John Forrest, that the matter could have been considered to come within the range of practical politics, and even then the question of cost seemed to have raised an insurmountable barrier until the marvellous development of the Colony's resources resulting from the gold discoveries on the now world-renowned Coolgardie and Kalgoorlie fields, and the consequent rapid increase of population and revenue, brought the idea within possible fruition. The enormous inward rush of passengers, goods, and mining machinery soon caused a block at Fremantle, and as hundreds of miles of railway were put in course of construction, great quantities of material had to be imported, thus intensifying the situation. The enlightened and progressive policy of the Forrest Government was, however, equal to the occasion, and having, fortunately, in their service a harbour engineer of the highest reputation, Mr. C. Y.

O'Connor, who had done valuable work in the North of Ireland and in New Zealand, he was put in charge, and the opening up of the mouth of the Swan, with the construction of the necessary protecting moles, was proceeded with.

It is not proposed to weary the interested reader with bewildering columns of figures, but, as instancing the marvellous progress made by this port during the past few years, the following summary referring to the value of the Imports will serve better than mere words to illustrate the position:—

During the three years ending 31st December, 1891, the total value of the Imports to the whole Colony of Western Australia was £2,972,667; while for the three years ending 31st December, 1898, the total value of the Imports landed *at the Port of Fremantle alone* was £13,341,089.

As a further illustration it may be mentioned that the total value of Exports from the whole Colony during the three years ending 31st December, 1891, was £2,232,671; while during the three years ending 31st December, 1898, the total value of the *Exports from the Port of Fremantle alone* was £4,442,446.

It should be mentioned here that the Imports and Exports of Fremantle were not separately noted in the Government statistics, as distinct from the other ports in Western Australia, previous to the year 1896.

As a further evidence of the enormous development of the trade of the port, the following figures speak volumes:—

The total tonnage of sailing vessels entering the Port of Fremantle during the years 1889, 1890, and 1891 amounted to 81,295, while during the three years 1896, 1897, and 1898 the total tonnage amounted to 203,609.

The total tonnage of sailing vessels cleared from the Port of Fremantle during the years 1889, 1890, and 1891 amounted to 55,848; while during the corresponding period ending 31st December, 1898, it amounted to 165,232.

These figures are eloquent enough to speak of the marvellous progress made by the port in such a short period, but they are again entirely eclipsed by the wonderful development in the steam vessel traffic. The following are the figures, and they speak for themselves:—

The total tonnage of steam vessels entering the Port of Fremantle during the years 1889, 1890, and 1891 was 35,051; while during a similar period, ending 31st December, 1898, it amounted to 527,019. As far as the Export trade is concerned, the total tonnage cleared from the port during the years ending 31st December, 1891, amounted to 8,670; while during the three years ending 31st December, 1898, the total was 545,644.

NOTE.—The above figures concerning the Import and Export trade do not include Coastal trade, but simply apply to the Intercolonial and Foreign business.

Still further referring to the foregoing figures, it is regrettable that the statistics have not been made complete to the end of 1899, as the inclusion of that year would show a still further and greater development. However, the following figures relating to the passenger traffic between Fremantle and the Eastern colonies and the outside world will speak with very great eloquence:—

During the three years ending 31st December, 1891, the immigration amounted to—Adults, 9,933, Infants, 1590; while for the three years ending 31st December, 1899, the influx of population amounted to 87,730 Adults, and 14,518 Infants.

The emigration during similar periods, that is, for the year ending the last day of 1891, amounted to 5,218 Adults, and 584 Infants; while for the three years ending 31st December, 1899, it amounted to 67,508 Adults, and 6,822 Infants; showing the balance of influx population over efflux of 20,122 Adults, and 7,696 Infants. It would therefore appear that, although the Port of Albany is nearer to the Eastern colonies, from where the bulk of the increased population was derived, the port of Fremantle still showed this enormous increase.

With reference to the marvellous developments of the Port of Fremantle as first and last port for vessels of all sizes, it is necessary to point out that only three years back a boat could not have entered the Swan River, that is, the Inner Harbour, if its draught exceeded 10 feet; while to-day the enormous vessels of the North German Lloyd, up to 10,500 tons register, have safely entered and departed from the new wharves on the South side of the inner basin. An enormous amount of money, amounting to about £1,000,000, has been expended by the Government of Western Australia in the construction of the Moles on the North and South sides of the entrance to the river, and on the deepening of the inner basin, and to complete these works (which to the eye of an ordinary commercial observer are unique South of the equator) it will require a further sum of about £250,000. This further expenditure, however, is provided for ungrudgingly by the Government and the Legislature of the Colony.

As already explained, the inner basin is sufficient to accommodate the magnificent steamers of the North German Lloyd, including the "Barbarossa," the "Koenigin Luise," the "Friedrich Der Grosse," and the "Bremen," each about between 10,000 to 11,000 tons, all of which vessels have successfully entered, berthed at the wharf, and departed from the basin without any difficulty whatever. When finally completed, the Inner Harbour, with its entrance protected by magnificent Moles which have been erected and are being extended, will consist of an inner basin 5,000 feet in length, 1,400 feet in width, and with a uniform depth of 30 feet at low water, Admiralty soundings. As a matter of fact the actual length of the shelter will be, from the extreme end of the North Mole to the inner end of the basin, 9,500 feet.

It is also part of the policy of the Government of the Colony to construct within this splendid basin, and without interfering

THE TOWN AND PORT OF FREMANTLE.

with its dimensions, a dock capable of serving the largest ships of Her Majesty's navy, or of the Mercantile Marine, visiting Australia.

The flagship of the Australian station, H.M.S. "Royal Arthur," has already visited the port, and was easily berthed at the South Quay in the Inner Harbour.

For many years this port had undeservedly enjoyed the reputation of being a dangerous haven. As a matter of fact the number of casualties have been infinitesimal compared with the number of arrivals and departures, but such was the extent of the bad reputation of the harbour that, when it was suggested to the North German Lloyd line that they should substitute Fremantle for Albany as their first port of arrival and their last port of departure in Australia, the ruling powers of the company ridiculed the idea. Some said it would be sending their ships to certain disaster if they entered such a dangerous port.

After repeated representations, however, this magnificent steamship organisation sent their head agent in Australia, Captain Mergell, formerly one of their commanders, to investigate matters, with the result that in a very short time Fremantle was chosen as their port instead of Albany.

Since that time (about two years) they have been making Fremantle their first port of call inwards and last outwards without a single casualty or hitch, and it is generally known in Australia that the profits of their Australian line have been very considerably enhanced thereby.

As pointed out elsewhere in this article, four (4) of their steamers, averaging about 10,500 tons, have repeatedly and successfully used the inner basin, going alongside the wharf without any difficulty and absolutely without danger or loss.

At the present time a discussion is going on as to the two great English mail steamer lines, viz., the P. and O. and the Orient, changing their port of call from Albany to Fremantle, and lately Fremantle had a visit from a special emissary of the P. and O. Company, Captain Angus, who after a most exhaustive examination notified to the Governing powers that he would report in favour of his company making Fremantle their port of call, provided that the other contributing Colonies and the Imperial Postal authorities agreed, also on condition that certain improvements in the Inner Harbour were guaranteed by the Colonial Government. These improvements are now in course of being carried out, and within the next few months will be *un fait accompli*. It is further anticipated that before the beginning of the year 1901 both of these companies will have substituted Fremantle for Albany as their port of call in West Australia.

The great commercial success made by the North German Lloyd, in making Fremantle their port of call two years back, has at last aroused the interest of the French line, the Messageries Maritimes, and at the time of writing a special representative from that great Company, Monsieur Cocholet, is visiting the Colony and making the

necessary inquiries as to the accommodation of the port. It is an open secret that the result of this gentleman's investigations will be that at an early date his Company will make Fremantle its first port of call, and last of departure in Australia.

It is an undoubted fact that the advent of the Messageries Maritimes steamers in the Port of Fremantle will be heartily welcomed by the business people and the travelling public generally.

A number of schemes had been proposed and considered with a view to providing a safe and commodious harbour, which could be entered and departed from at all hours of the day and night, and in all weathers, with the final result that the Government decided on opening up the mouth of the River Swan; and the work having been once entered on has been carried on with the utmost vigour, the dredging going on day and night, altogether five dredges being at work.

All the expert visitors who have inspected the works have unanimously commended what has been done and approved of what is to be done.

There is a magnificent wharf on the South side of the basin 4,575ft. in length, which is being still further extended. This wharf and the adjoining railway sheds and yards are well lighted by an electric installation provided by the Railway Department.

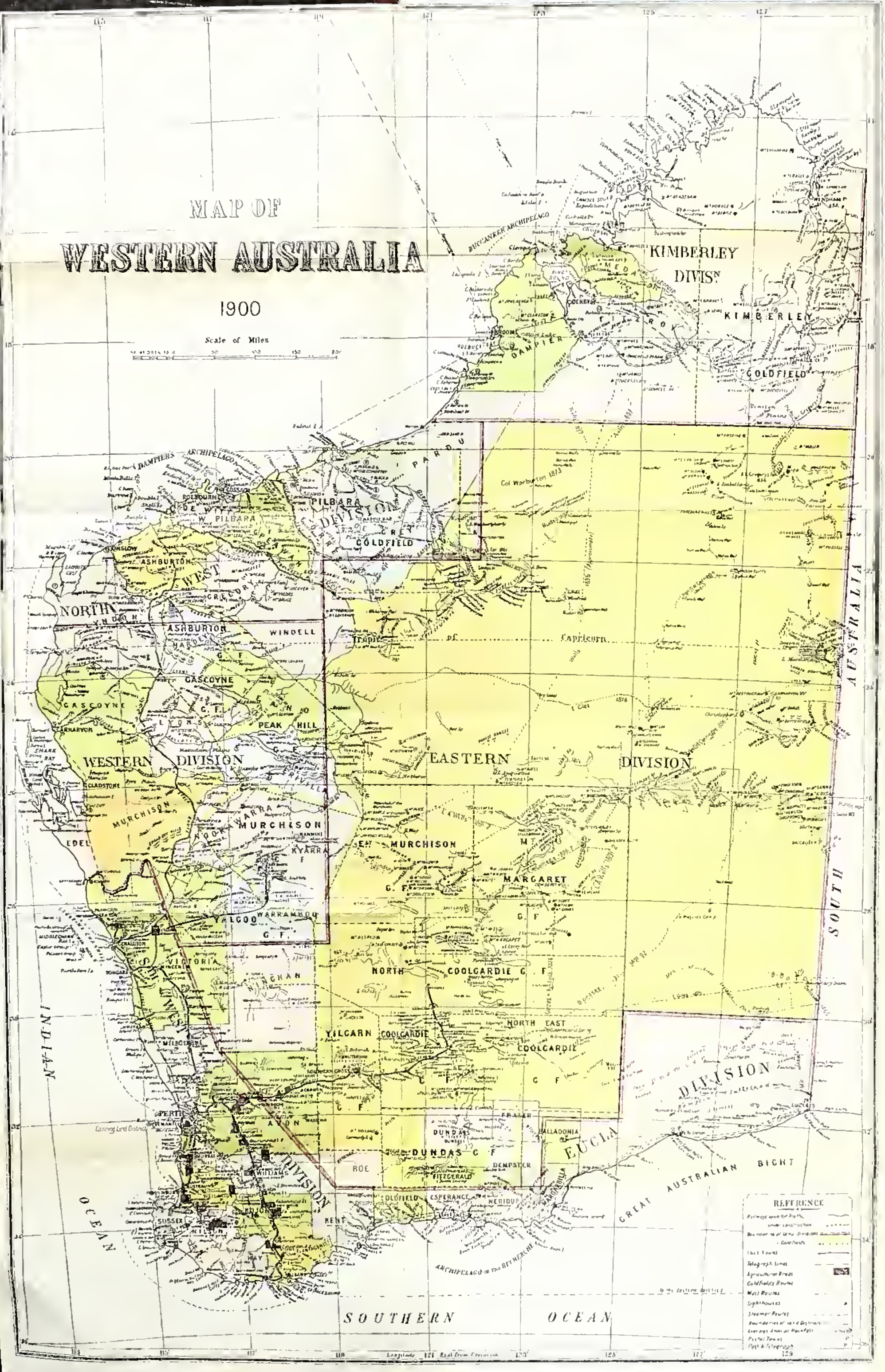
On the North side special jetty wharves are being constructed for the use of mail steamers in the winter season, when an occasional North-Westerly gale might cause the approach to and the departure from the South Quay to be rather troublesome. So far, however, no apparent need for this extra protection has arisen, as the largest steamers visiting Australia have been able to enter and leave the harbour at any hour of the day or night, and in all weathers.

There is a first-class pilot service from the pilot station on Rottnest Island, about 12 miles from the port, the channel from there to the Inner Harbour entrance being of a great depth and perfectly safe in all weathers.

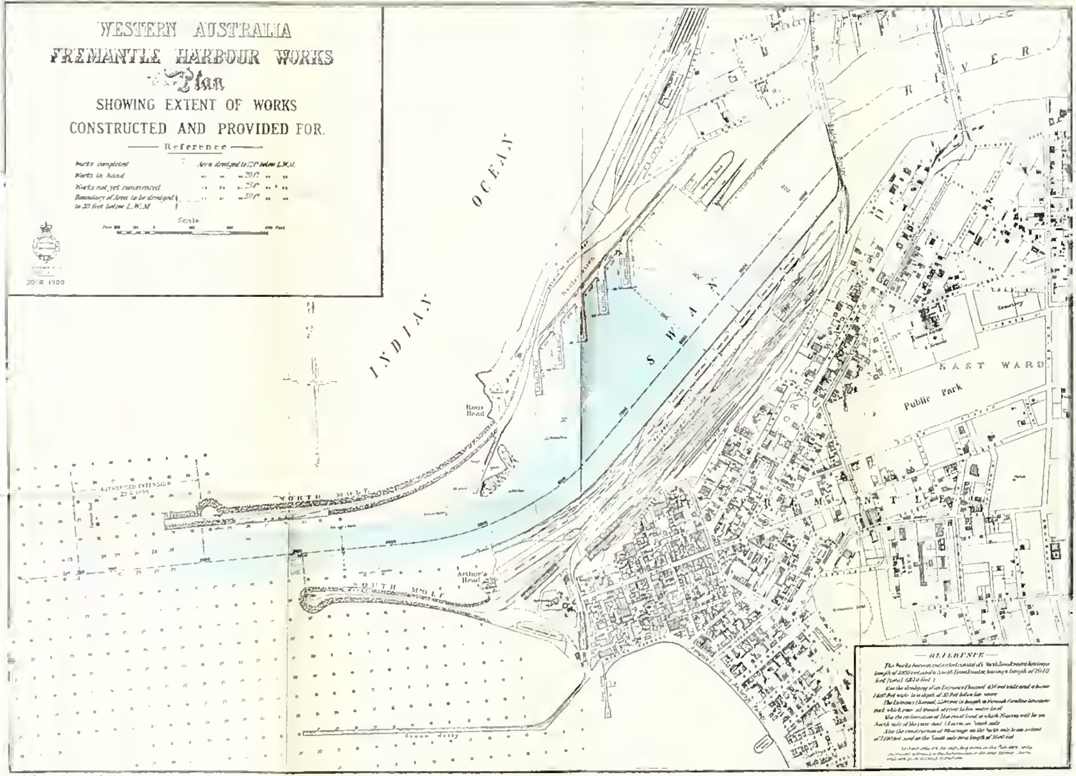
The anchorage outside in the Roads is also of the very safest description, vessels riding at anchor in perfect safety during the heaviest gales, but of course the construction of the Inner Harbour has done away with the necessity of ships availing themselves of the Roads for loading and discharging.

The town and suburbs have an ever-increasing population, at present numbering fully 20,000, and is governed by three municipalities, the streets being well kept and some of them paved with jarrah blocks. There is also a capital water scheme for the town and shipping. An English company has obtained a concession for electric lighting and tramway services, and the necessary work will be proceeded with this year, and completed probably before the beginning of 1901.

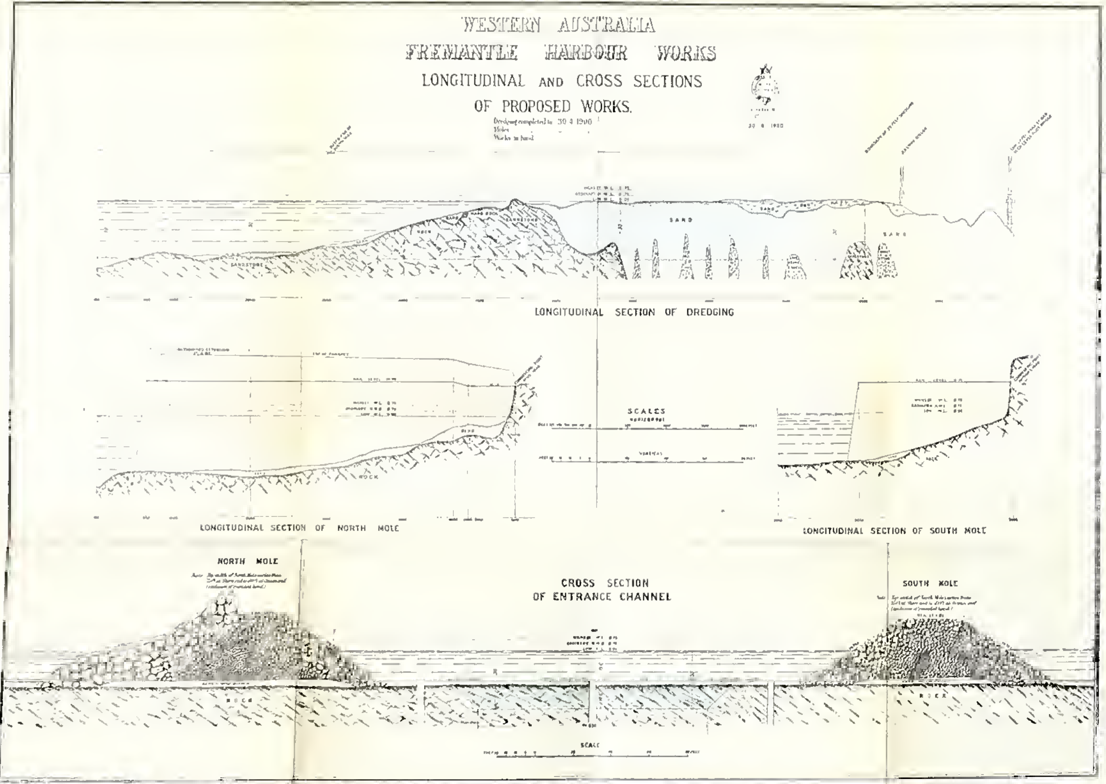
By Authority: Richard Pether, Government Printer, Perth.



MAP OF
WESTERN AUSTRALIA
1900
Scale of Miles
KIMBERLEY DIVISN
KIMBERLEY
GOLDFIELD
PILBARA DIVISION
GOLDFIELD
W. PILBARA
ASHBURTON
NORTH
WEST
ASHBURTON
WINDELL
GASCOYNE
PEAK HILL
WESTERN DIVISION
MURCHISON
EASTERN
DIVISION
MURCHISON
MARGARET
YALGOO
WARRAMBOO
G.F.
VICTORIA
NORTH
COOLGARDIE G. F
YILGARN
COOLGARDIE
NORTH EAST
COOLGARDIE
DIVISION
PERTH
AVON
DUNDAS
DUNDAS G. F
ROE
DEMPSTER
EUCLA
GREAT AUSTRALIAN BIGHT
SUSSEX
WILLIAMS
KENT
ESPERANCE
FITZGERALD
INDIAN
OCEAN
SOUTHERN
OCEAN
SOUTH
AUSTRALIA
Tropic of Capricorn
REFERENCE



WESTERN AUSTRALIA
FREMANTLE HARBOUR WORKS
Plan
SHOWING EXTENT OF WORKS
CONSTRUCTED AND PROVIDED FOR.
Reference
Works completed
Works in hand
Works not yet commenced
Boundary of Area to be dredged to 30 feet below L.W.M.
Scale
30 4 1900
INDIAN OCEAN
SWAN RIVER
Roux Head
Arthur's Head
NORTH MOLE
SOUTH MOLE
EAST WARD
Public Park
FREMANTLE


WESTERN AUSTRALIA
FREMANTLE HARBOUR WORKS
LONGITUDINAL AND CROSS SECTIONS
OF PROPOSED WORKS.
SAND
LONGITUDINAL SECTION OF DREDGING
SCALES
ROCK
LONGITUDINAL SECTION OF NORTH MOLE
LONGITUDINAL SECTION OF SOUTH MOLE
NORTH MOLE
CROSS SECTION
OF ENTRANCE CHANNEL
SOUTH MOLE
ROCK
SCALE

THE following pages contain a reprint of a work entitled

THE MINERAL WEALTH

OF

WESTERN AUSTRALIA,

Written by A. Gibb-Maitland, Government Geologist of the Colony, issued under authority of the Hon. H. B. Lefroy, M.L.A., Minister of Mines, and inserted in this Handbook as a reliable and official account of the mineral resources, development, and present status of the mining industry in Western Australia.

1900.

WESTERN AUSTRALIA.

GEOLOGICAL SURVEY.

BULLETIN No. 4.

THE MINERAL WEALTH

OF

WESTERN AUSTRALIA,

BY

A. GIBB MAITLAND, F.G.S.,
GOVERNMENT GEOLOGIST.

Issued under the authority of the Hon. H. B. Lefroy, M.L.A., Minister of Mines.

PRELIMINARY ISSUE.

PERTH:
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1900.

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA.

LIST OF OFFICERS.

Government Geologist	...	A. Gibb Maitland.

Field Staff:

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Topographical Surveyor	...	W. D. Campbell, A.M.I.C.E., L.S., F.G.S.
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Laboratory Officials:

Mineralogist and Assayer	...	E. S. Simpson, B.E., F.C.S.
Laboratory Assistant	...	C. C. Williams.
Cadet	...	H. Bowley.

Office Staff:

Draftsman... ...	...	R. H. Irwin.
Clerk and Accountant	...	F. J. Kelly.
Messenger	...	G. O. Bailey.

TABLE OF CONTENTS.

PREFATORY NOTE.

THE Mining Handbook written by my predecessor having been for a long time out of print, it has been deemed necessary, owing to the growing demand for some concise official information with reference to the Mineral Resources of the Colony, to issue a new edition.

After careful consideration, it was found better to prepare practically a new work, which would embody all the latest official information as to the Mineral Resources of Western Australia.

Owing to the vast area of the Colony, and the exigencies of travel, it has not been possible for me, as yet, to examine even in a most cursory manner all portions of Western Australia, hence the information with reference to certain districts—more especially that promising area between the Gascoyne and the DeGrey Rivers—is not so ample as could be wished.

The pamphlet is accompanied by a series of plans illustrating the geology of certain of the mineral fields, and a coloured map showing the distribution of the useful minerals, together with the location of the different goldfields and mining districts.

The statistics, as to the Mineral Production of the Colony—without which the pamphlet would have been incomplete—have been taken from official sources.

In addition to the work of the Geological Survey, I have freely availed myself (with due acknowledgment) of the labours of my predecessors, as well as the other unofficial observers, by whose researches our knowledge has been materially increased.

A compilation of this nature affords little scope for originality, but an attempt has been made to present a faithful account of the Mineral Wealth of the Colony, and to indicate those localities awaiting the attention of all classes of the mining community; it is for others to judge how far this has been accomplished.

A. GIBB MAITLAND,
Government Geologist.

Geological Survey Office, 22nd January, 1900.

CHAPTER I.

The Salient Geological Features of Western Australia.

INTRODUCTION, ARCHÆAN, CAMBRIAN, SILURIAN, DEVONIAN, CARBONIFEROUS, MESOZOIC, CAINOZOIC, VOLCANIC ROCKS.

Introduction.

The Mineral Resources of a country being so intimately associated with its geology, it is natural that any account of the former should be dealt with only after its geological features have been properly understood. This account of the salient geological features of Western Australia must, however, be regarded more in the light of a statement of the present condition of our knowledge than a detailed memoir thereon, and should serve to show how much has yet to be learnt on the subject.

Certain very small portions of the Colony which are of economic importance have in late years received somewhat detailed investigation, but there are many portions which are as yet only imperfectly known, while by far the larger area of the Colony has never yet been examined by any trained geologist, and many years must elapse before even the dominant geological features can be grasped.

In the compilation of this account I have freely availed myself of the work of my predecessors and of those other scientists to whom Western Australian Geologists owe a debt of gratitude. As this article is to a large extent based upon the labours of previous official geologists, it is not out of place to give a succinct account of their observations.

Dr. F. von Sommer would appear to have been the first official geologist employed in the Colony. This gentleman travelled extensively during the years 1847 to 1857 throughout the Colony. He geologically examined the Victoria, Toodyay, and York Districts, and extended his observations to the country lying between the latter and Mt. Barren, on the South Coast. Neither the maps nor reports of this worker have ever been published, although three articles from his pen bearing upon the geology of the Colony have appeared in the pages of current literature during the years 1848 and 1849.*

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* *Vide* "Bibliography of the Geology of Western Australia." A. Gibb Maitland, Perth: By Authority, 1898.

After an interval of 21 years, during which much excellent geological work was accomplished by the Gregory Brothers, H. Y. L. Brown was appointed to the post of Government Geologist. This officer, during the years 1870-71, prepared three geological maps and issued ten reports (now out of print), all of which have been laid under contribution in the preparation of this *résumé*.

In 1882 E. T. Hardman, of the Geological Survey of Ireland, was appointed Government Geologist. His labours were chiefly confined to the Kimberley District, upon which he issued two voluminous reports illustrated with a series of maps and plates. Mr. Hardman's researches laid the foundations of our knowledge of the geology of the Northern portion of the Colony, and also led to the discovery of the Kimberley goldfield. This officer examined the neighbourhood of Bunbury, Blackwood, etc., and investigated the vicinity of Perth with reference to the question of its water supply from subterranean sources.

The late Rev. C. G. Nicolay contributed largely to our knowledge of the geology of the Colony, and was the founder of the Geological Museum in Fremantle, now merged into the Perth Museum.

In 1887 H. P. Woodward was selected to fill the post of Government Geologist. Mr. Woodward, in the course of his official duties (1887-1895), travelled over the length and breadth of the Colony and, with a small appropriation, published 21 voluminous reports and six geological maps.

Archæan Rocks.

The oldest formation in Western Australia is that comprising those gneissic, granitoid, and schistose rocks, which cover such an enormous area of the country, and form the floor upon which the newer strata have been laid down. To the whole of these metamorphic rocks observers have invariably assigned an Archæan Age; this, however, is more inferred than proved. There is only one instance on record, at the present time, upon which this classification may be considered to have been determined by palæontological evidence.

In the Kimberley District certain limestones, sandstones, quartzites, etc., have yielded Lower Cambrian fossils, viz. *Salterella Hardmani* and *Olenellus* (?) *Forresti*. These fossiliferous beds are considered, and may probably be, newer than the gneissic and schistose rocks in the vicinity. So far as observations have at present been carried, no actual junction has been noticed between the schists and the fossiliferous strata, and there is nothing already in the evidence available incompatible with the supposition that the talcose and mica schists and other associated rocks represent much more highly metamorphosed portions of the Lower Cambrian Beds.

In the absence of direct stratigraphical or palæontological evidence, it is convenient for descriptive purposes to adhere to a purely lithological classification, and to separate the gneissic, granitoid, and schistose rocks from those in which metamorphism has not been carried sufficiently far to entirely obliterate their clastic character.

These Archæan rocks have been thus described by H. P. Woodward, formerly Government Geologist:—

This great group of rocks are more largely developed in this Colony than in any other portion of the world, outcropping as they do in all parts of the country, and where they are overlain by more modern formations these latter are rarely of any great thickness. This series is highly contorted, being folded into a number of parallel anticlinal and synclinal folds, striking North and South, and often presenting the appearance of a highly inclined dip, which is either nearly vertical or trending to the Eastward. These rocks are much broken and faulted by numerous diorite and granite dykes; they contain many quartz veins and iron lodes, and it is in this group of rocks that the principal auriferous deposits exist. This great series of rocks may be subdivided into three sections—the granites, the gneisses, and the schists, which, as a rule, run in parallel belts North and South, with a slight trend to the North-West.

The first, or Western belt, extends from the Murchison River to the South Coast, but is very little exposed, except in the Northampton District, and a little South of the Irwin River, where it is rich in copper, lead, and zinc lodes. It underlies the sandy coastal plains, outcropping here and there at the base of the Darling Range, forming a small range between the Capes Naturaliste and Leeuwin, and characterised throughout by lead, copper, and zinc lodes. The rocks of this belt are, for the most part, comparatively soft, consisting of clay-slates (often kaolinised), quartzites, and schists, with dykes of diorite and granite, and veins of quartz, containing lead, copper, zinc. iron pyrites, and ferruginous graphite.

The second belt extends Northward from the South Coast (forming the bold escarpment at the edge of the great plateau called the Darling Range) as far as the Murchison River. It then follows this river in a narrow belt in a North-Easterly direction for about 200 miles, where it suddenly spreads out to the East and North-West from the Robinson Range to the Lyons River, disappearing beneath the magnesian limestones to the Northward. In this belt the rocks are mostly hard and crystalline, consisting principally of gneiss and schist, with dykes of diorite, granite and felstone, and veins of quartz. The latter (as well as the diorite) often contains large quantities of pyrites. most of which yield a little gold. Tin is also being worked at the Greenbushes Tinfield, the ore being derived from the disintegration of quartz-porphyry dykes, in which it is associated with tourmaline and titanic iron. Besides iron and manganese, large deposits of kaolin of a very fine quality occur, as well as veins containing mica and asbestos; but these latter are too much weathered at their outcrop to be of any value. Near Bridgetown a very large deposit of graphite has lately been opened up; it exists in the form of a bed between talcose schists, about 20 feet in thickness.

The third, or great granite belt, lies about 100 miles East from the West Coast, and is about 100 miles in width, extending from the South Coast to the Murchison River. It consists of a series of bold, bare outcrops of gneiss or granite, often 100 feet in height, and covering several hundred acres in extent, rising from loamy flats. The rocks mostly outcrop in the depressions of the table-land, the higher portions of which are covered by sand plains. This belt is absolutely destitute of mineral veins, and it is due to this barrier that the rich goldfields to the Eastward remained so long unprospected. These outcrops are made use of for the conservation of water in

this dry portion of the Colony, as they shed water like a house-roof, whilst around them there are many natural dams or basins filled with sand, which are either being cleaned out or wells are being sunk in them. The rocks of this belt consist entirely of gneiss and granite, much fissured and faulted, and traversed by numerous dykes of granite and diorite, whilst the main masses generally enclose fragments and masses of schistose and gneissic rock.

The fourth, or *first auriferous belt,* is situated immediately to the Eastward of the granite belt, and is about 20 miles in width. It starts from the South Coast at the Phillip's River, extending Northward in a narrow belt by the Ravensthorpe Range, Parker's Range, Southern Cross, Golden Valley, Mt. Jackson, Mt. Kenneth, Mt. Magnet, Austin's Lake to Cue. Thence it takes a slight bend to the North-East to Nannine and the Star of the East, where it strikes more to the North, and skirting round the heads of the Murchison and Gascoyne Rivers, it turns North-West and follows down the Ashburton Valley to its junction with the Henry, finally disappearing beneath the Palæozoic formation. The rocks of this belt consist mostly of hornblende, mica, or talc schists, of which the hornblende schists so closely resemble diorite that it is impossible to distinguish it in a broken specimen. The rocks of this belt are a good deal broken and faulted by granite and diorite dykes, and quartz lodes containing gold, iron and copper. There are also some large magnesia lode-masses, rich in fine gold, which will probably prove to be serpentine at a depth. Many of the lodes also contain large quantities of chlorite.

The fifth, or second granite belt is about the same width, and similar in every way to the first mentioned. It extends from the South Coast, following the line of the first auriferous belt North, and, like it, dipping under the Palæozoic tableland of the Fortescue. Only a small portion makes its appearance on the Northern side of the Yule River, near Pilbarra, upon the North-West Coast.

The sixth, or *second auriferous belt*, lies next, and at present its width is unknown, but it is certainly of considerable width in places, and has proved, wherever prospected, to be extremely rich in gold. It extends North from the Dundas Hills (where this formation first outcrops from below the sand plains) by Wagemulla,* Coolgardie, and Three Pinnacles, Ularring, Lake Carey, and following about the same line as the other belts, and turning with them to the North-West by the Nullagine, Marble Bar, Pilbarra, Egina, and Mallina upon the North-West Coast. The rocks of this belt are generally very similar to those of the first auriferous belt, but the formation and lodes are a great deal more faulted and broken; however, to make up for this, they are the richest that have ever been discovered.

The hornblende rocks of this Colony are very remarkable in character, being met with most abundantly from North to South. They vary immensely in colour, structure, and external character, some at first glance having the appearance of clay-slate, but on being fractured they exhibit a structure similar to diorite, whilst others again only contain green crystals of hornblende disseminated through a quartz matrix, or have a jade-like appearance, which latter variety are continually being mistaken for copper, nickel, or silver. With these rocks are associated the principal mineral deposits of the Colony—gold, tin, copper, antimony, lead, zinc, manganese, and iron.

The spur of which Magpie Hill, in the Porongorup Range to the North of Albany, forms the highest summit, trends generally North-West and South-East, which is practically coincident with that of the foliation of the granitic gneiss; but what is of signifi-

* (?) Widgiemooltha.

cance is that the trend of the foliation has determined that of the longer axes of the felspar crystals.

In the Pilbarra Goldfield there are distinct traces of a double foliation in the gneiss, which is particularly well seen in the bed of the Big Sherlock River, where it is crossed by the road to Mallina. The older and coarser banding has a North and South strike at the Big Sherlock section, and at right angles to this are zones of secondary and much finer foliation, within which it has the character of a mylonite or a fine quartz schist, perfectly distinct from the original rock.*

Cambrian Rocks.

An undoubted Cambrian fauna has been discovered in the rocks of the Kimberley District. The fossils consist of *Salterella Hardmani* and *Olenellus (?) Forresti*, and are associated with certain limestones, sandstones, quartzites, clay slates, and sandy flags. Very little is known of these Cambrian Rocks at present; their superficial area, however, would seem to be extensive, for they have already been proved to extend in a North-East and South-West direction from the Burt Range and for some distance to the Southward of Mount Dockrell. No estimate has yet been made of the thickness of these the oldest fossiliferous beds yet found in the Colony. The strata have been tilted in such a way that the principal axes of folding is North-West and South-East.

The Cambrian Rocks of Kimberley are of considerable economic importance, in that they form the matrices of those auriferous quartz reefs which have already been exploited. As can be seen by reference to a later page, a fairly large quantity of gold has been returned from this district. Although the figures include a considerable quantity of alluvial gold, it is a natural assumption that this was originally derived from the disintegration of the Cambrian beds.

Silurian Rocks.

The occurrence of Silurian Rocks in Western Australia has been more inferred than proved.

Writing in 1861, F. J. Gregory described certain rocks of the Mount Barren Range as being probably of Silurian Age, though the evidence upon which this deduction is based was not given.

The rocks of the Stirling Range, which lies about 50 miles North of Albany, have been claimed as Silurian. The beds consist of quartzites, sandstones, and shales, the whole being traversed by quartz veins. The beds are highly folded, contorted, and faulted in places. According to the researches of H. P. Woodward, the rocks at the Western end of the Range, near Mondinup, have been thrown into three sharp anticlinal and synclinal folds, in a distance North and South of about 10 miles, by a lateral compression from the South.

* The Geological Features of the Coast of Western Australia. H. M. Cadell, Trans. Geol. Soc., Edin., 1896.

This series of rocks, although covering a considerable area, are plicated in such a manner that two or three beds form the entire range, rising abruptly from beneath the plain to the Northward, and dipping under it again to the Southward . . . . *

The strata chiefly developed in the Leopold and Mueller Ranges of Kimberley, have been provisionally classed as Silurian, more, however, on account of their lithological character than on any stratigraphical or palæontological evidence.

The rocks composing the Leopold and Mueller Ranges are of various textures. They are sometimes pure crystalline quartzites, and sometimes fine grained but highly indurated grits, having an almost vitrified appearance. Coarse pea-grits, and quartzose conglomerates are everywhere met with, but as a rule the whole mass shows indication of extreme metamorphic action. Interbedded with these however, we meet with beds of soft sandstones, and purple slates, which have apparently suffered no alteration whatever.†

Much detailed fieldwork is, however, required before the occurrence of undoubted Silurian Rocks in Western Australia can be considered to have been definitely proved.

Devonian Rocks.

The Devonian Rocks of Kimberley have been described by E. T. Hardman as consisting of hard grits, conglomerates, indurated limestones and shales. They are seen to rest unconformably upon a series of schists and slates which have been claimed as being of Lower Silurian Age; they are covered by basaltic lavas which are in turn partly overlaid by undoubted Carboniferous Rocks. The Devonian Strata occupy an area of about 2,000 square miles, and calculations have shown that their thickness is about 10,000 feet.

The Kimberley Devonian Rocks have yielded the following fossils:—*Actinostroma clathratum, Stromatoporella Eifeliensis, Pacypora tumida, Cyathophyllum virgatum, Cyathophyllum depressum, Aulopora repens, Spirorbis omphaloides, Spirifera, Atrypa reticularis, Rhynchonella pugnus, Rhynchonella cuboides, Orthoceras, and Goniatites.*

Associated with these sedimentary beds are contemporaneous basalts, dolerites, anamesites, volcanic breccias and ashes. These volcanic rocks extend over a large area of country, and also attain a considerable thickness, having been estimated to reach from 1,000 to 1,100 feet. No undoubted volcanic focii have been observed in the district over which these lavas extend, though certain peaks and cones have been mentioned by Mr. Hardman as being likely to prove on detailed examination to be ancient volcanic vents.

* The Country between Broomehill and the Dundas Hills, and the Mines in that neighbourhood. H. P. Woodward. *Ad interim* Report on the Department of Mines for the half-year ending 30th June, 1894. Perth: By Authority: 1894; p. 14.

† On the Geology of the Kimberley District. E. T. Hardman, Perth: By Authority: 1885; p. 23.

Carboniferous Rocks.

The Carboniferous Rocks of Western Australia cover a very large area of country and seem to be particularly well developed in the Kimberley District. The formation is divided into an Upper or Sandy, and a Lower or Calcareous Series.

The occurrence of the Carboniferous formation would seem to have first been published by Sir George (then Lieut.) Grey in the year 1841, in his journals of Two Expeditions of Discovery in North-West and Western Australia during the years 1837-39. Dr. F. Von Sommer, the first Government Geologist of the Colony, traced the Carboniferous Beds, in 1848, from the heads of the Irwin River to those of the Moore, for a distance of about 160 miles.

There are three distinct districts in which fossiliferous Carboniferous Rocks are known in the Colony, viz., Kimberley, the Gascoyne, and the Irwin River District.

The Kimberley Beds.—The Carboniferous Rocks of Kimberley are represented by wide-spread deposits of sandstones, grits and conglomerates, all containing bands and nodules of hematite or ironstone, as well as magnesian and other limestones.

The Upper or Sandy Series, according to E. T. Hardman* by whom these beds were first described:—

> Extends from Roebuck Bay, on the West, to the Napier and Oscar Ranges on the East, and is recognised alike on the North side of Stokes Bay. and in the St. George Ranges 100 miles to the South . . . . . It may reasonably be asserted that this Sandstone formation is considerably over 1,000 feet in thickness, for the Grant Ranges have an elevation of over 900 feet above the plain, while the nearest limestone is 60 or 70 miles distant; and probably its continuation lies (even assuming a moderate angle by dips) many hundreds of feet below the Sandstones of the Grant Range and Mount Anderson. The sandstones here dip at high angles, so that the thickness of strata is considerably more than the actual height of the hills above the plain. . . . . Besides those on the Fitzroy it occupies a considerable portion of the Haughton Ranges, which extend for some 35 or 40 miles. It is next seen in the Ord District, along the North-West of which it stretches for over 50 miles in length, with a minimum width of about 20. Here it rises into high ranges, of which Dixon Range and the Hills marked J39 are prominent examples. Hardman Range, to the South, is also composed of it. Further North the strip of country extending from Mount Elder along the Negri to the South of Mount Panton is mainly composed of this formation, although occasionally subordinate bands of limestones are met with in these rocks.

Of the Carboniferous Limestone (Lower) Series the same author writes:—

> This formation extends in a wavy line from Alexander Creek through the Napier Range, Oscar Range, Geikie Range, etc., from North-West to South-East, as far as the Margaret River, ending within a few miles of the Leopold Range. In this direction it is at its widest, as its breadth may be estimated from the various outcrops and ranges above the plains at 30 miles. It gradually narrows northwards, and at Napier Range is not more than seven miles wide; this includes the portion hidden beneath alluvium, etc.; but the limestone comprising the range itself is not more than two

* The Geology of the Kimberley District, Western Australia. Perth: By Authority: 1885.

miles in width. The general character of the limestone is the same throughout. It is light-coloured, compact, brittle, splintery, more or less magnesian limestone. In colour it varies from light grey to flesh colour, and sometimes pink. For the most part it is massively bedded, and it is not always easy to discern the direction of the bedding, as it is cut through by numerous joint lines, and often coated with stalagmite. The general appearance it presents is that of a very rugged vertically bedded rock, in consequence of these joints; the summits of the ranges being worn into points, pinnacles, and other fantastic shapes. On examination, however, it is seen that the rock dips at a very moderate angle, varying from 5° to 25°, the direction of the dip being usually at right angles to the trend of the hills. The limestone is interbedded with many thick layers of shale and thin arenaceous limestone; but these only occur in the lower beds, at the base of the hills.

Further to the East the Carboniferous Limestone appears in great force in the Rough Range, and extends to the South-East towards Haughton Range, a distance of nearly 30 miles. The extent of the limestone laterally, that is to the South-West, is not known, but in many places it is seen for 6 or 8 miles, and South-West of Mount Huxley it stretches from its Eastern edge, near J8, for nearly 20 miles in that direction. The limestone crops up at intervals between this range and Mount Pierre to the northwards, and is seen in various parts of the River Margaret, extending in rather high hills on the North of that river, both to the East and West (Hull Range, Mount Krauss, etc.).

The Carboniferous Limestone Series of the localities above described:—

Consist in great part of rather massively bedded light grey and sometimes flesh coloured limestone, often magnesian, but interbedded with thin, flaggy, earthy, and sometimes sandy limestone. But these chiefly occur among the lower beds, and are often interstratified with dark grey sandy shales. The valley of the Margaret is mainly composed of thin, flaggy, hard limestone (which gives a bell-like sound when struck with the hammer), earthy fetid limestones and shales with nodular limestone bands.

From the last mentioned locality no Carboniferous Limestone makes its appearance for a distance of about 120 miles.

A short way below the junction of the Panton and Elvire Rivers limestone again makes its appearance, and occupies a wide area extending as far North-Easterly as for several miles beyond the Negri, in all about 75 miles; while in width it averages from 20 to 30 miles. This portion of the limestone country rises in a succession of low and almost imperceptible terraces into high tablelands. One of these extends to the East of the Ord near the cattle station, and another to the North and East of the Negri River where it is capped by Mount Panton. The Ord limestones are for the greater part hard and flaggy, rarely massive, usually grey in colour, sometimes sandy or magnesian, and seldom fossiliferous. In many parts of the district they are interbedded with red shales, marls, and sandstones, the former of which contain occasionally layers of gypsum together with traces of rock salt.

The Carboniferous beds of Kimberley have yielded the following fossils:—*Lepidodendron*, sp.; *Stigmaria*, sp.; *Stromatopora concentrica* (?) *Stromatopora placenta*, sp.; *Pachypora tumida*; *Zaphrentis*, sp.; *Syringopora*, sp.; *Actinocrinus*, sp.; *Platycrinus*, sp.; *Poteriocrinus crassus*, Miller; *Pentremites*, sp.; *Serpula*: *Spirobis*, sp.; *Fenestella plebeia (antiqua)*, M'Coy; *Productus*, *giganteous*; *Productus longispinus*; *Productus semireticulatus*; *Chonetes*, sp.; *Chonetes Hardrensis*; *Discina*; *Orthis resupinata*;

Strophalosia Clarkei, Eth. fils ; *Rhynchonella pugnus ; Rhynchonella pleurodon ; Rhynchonella cuboides ; Orthotetes crenistria*, Phillips ; *Streptorhynchus crenistria ; Terebratula hastata* (?) ; *Terebratula sacculus* (?) ; *Pleurotomaria*, sp. ; *Toxonema*, small sp. ; *Natica*, sp. ; *Ceriopora*, sp. ; *Chaetetes tumidus ; Stenopora Tasmaniensis ; Cyathophyllum*, sp. ; *Cycthophyllum virgatum ; Cyathophyllum depressum ; Lithodendron affine.*

The Gascoyne Beds.—The strata of the Gascoyne River consist of a series of crystalline limestones, full of corals, dipping at an angle of about 10 degrees to the Westward. Beneath these are shales, which yield Lower Carboniferous fossils. At the base of the series is a boulder conglomerate resting upon clay slates or shales. The boulders in the conglomerate are of crystalline rocks. No detailed examination of this important district having been made, our information with reference to the beds is extremely meagre.

The following is the list of fossils from the Gascoyne River beds :—*Pachypora tumida*, Hinde ; *Zaphrentis*, sp. ; *Amplexus pustulosus*, Hudl. ; *Amplexus nodulosus*, Phil.; *Syringopora reticulata*, Goldf. var. *patula ; Stenopora Tasmaniensis*, Londs ; *Cyathocrinus*, sp. ; *Poteriocrinus crassus*, Miller ; *Fenestella plebia (antiqua)*, M'Coy ; *Polypora Australis*, Hinde ; *Protoretepora ampla*. Lons. ; *Rhombopora tenuis*, Hinde ; *Evactinopora crucialis*, Hudl.; *Edestus Davisii*, H. Woodward ; *Aviculopecten Illawarensis*, Morris ; *Aviculopecten limaeformis*, Morris ; *Athyris Roysii*, Leveille ; *Athyris Macleayana*, Eth., fils.; *Spirifer striatus*, Martin ; *Spirifer* cf. *crassus*, Konin ; *Spirifer vespertilio*, G. Sow. ; *Spirifer cf. convolutus*, Phil. ; *Spirifer Kimberleyensis*, Foord ; *Spirifer lata*, M'Coy ; *Spirifer Hardmani*, Foord ; *Spirifer Musakheylensis, Dav.* Var. *Australis ; Syringothyris exsuperans*, de Kon.

The Irwin River Beds.—The existence of Carboniferous Rocks on the Irwin River would seem to have first been noted by Mr. Surveyor Gregory some time during the year 1846. Dr. F. Von Sommer, then Government Geologist, examined and reported on the scene of Gregory's discovery, and traced the formation from the head of the Irwin to the Moore River, a distance of about 160 miles.

The area was mapped in 1895 by H. P. Woodward, who at that time occupied the post of Government Geologist. This gentleman reports that the Carboniferous Rocks extend

From Mingenew in an Easterly direction, covering an area of about 20 square miles, its greatest length from North to South, from Badgeree Pool upon the North branch to Mount Scratch, being about 30 miles, whilst the greatest width from Mingenew to Narandagry, upon the Lockyer River, is about 17 miles. To the North-West this area is bounded by the high sandy tableland which extends away to the Northward as far as the Greenough River. The South is bounded for the most part by the low outcrops of metamorphic rock, which contains many copper lodes ; to the Eastward by the bold escarpment of crystalline rocks, flanked by horizontally bedded

Tertiary Sandstones, which often present towards the plains vertical cliff faces of as much as 200 feet, particularly where streams have cut deep channels through them; whilst to the Westward it is bounded by more high sandy plains which extend as far as the coast.

The Carboniferous Rocks of the Irwin River have yielded the following fossils:—*Pleurophyllum Australe*, Hinde; *Pleurophyllum sulcatum*, Hinde; *Fenestella*, sp.; *Productus tenuistriatus*, Vernueil; *Productus subquadratus*, Morris; *Productus undatus*, Defrance; *Chonetes Pratti*, Dav.; *Spirifer Musakheylensis*, Dav. var. *Australis*; *Syringothyris exsuperans*, Konin; *Reticularia lineata*, Martin; *Reticularia crebristria*, Morris; *Orthotetes crenistria*, Phil.; *Pachydomus carinatus*, Morris; *Aviculopecten*, sp.; *Modiola*, sp.; *Edmondia*, sp.; *Sanguinolites*, sp.; *Bellerophon decussatus* (?), Flem.; *Orthoceras*, sp.; *Discites*, sp.

Mesozoic Rocks.

The existence of rocks containing a secondary fauna would seem to have been first made known in the year 1861 by F. T. Gregory, in a paper communicated to the Geological Society of London by Sir Roderick Murchison. Mr. Gregory says these beds:—

Are almost exclusively siliceous in character, containing only a few beds of chalk of very inferior quality. They abound, however, more in fossils than the Carboniferous do, and with the exception of the recent coast limestone, more so than any other formation. Flints are rarely found in these. The bed of the Greenough River is the best spot for procuring specimens, although a few are found in the Chalk Hills near Gingin (spines of Echinoderms, etc.).

Writing in 1863, Charles Moore observes that the bulk of the Mesozoic fossils from the Colony are of Jurassic Age, but in 1870, in a paper read before the Geological Society (of London), he expresses the opinion, based upon fossil evidence, that Cretaceous rocks occur in addition to those of Jurassic Age. Since that date, however, very few sectional details have been given of the Mesozoic Rocks of the Colony, although a fair collection of fossils has been made. These beds have been studied in the field by H. Y. L. Brown, who thus describes the strata, which he claims to be of Oolitic Age:— *

The character of the Strata belonging to this Period may be described as follows:—Beds of highly ferruginous claystone or shale, sandstones, grits, conglomerates, clays and limestone, placed in horizontal layers upon the older rocks, which originally they must have almost entirely covered, but have since been cut into and denuded to a great extent from off them, in such manner as to leave tablelands, isolated tablehills, and peaks with steep escarpments and slopes. Their average elevation is about 600 feet above sea level. The surface of this formation is generally coated with a deposit of sand, arising from the weathering of the sandstones, the larger areas being known by the name of sandplains. There are two principal areas occupied by this formation. The first, which varies in width from 10

* General Report on a Geological Exploration of that portion of the Colony of Western Australia lying Southward of the Murchison River and Westward of Esperance Bay. Perth: By Authority: 1873; pp. 11-14.

to 30 miles, extends from the neighbourhood of Gingin and Yatheroo to the Murchison, and probably a long distance further Northward, in a line more or less parallel to the coast. Proceeding Eastward, it thins out and only exists there as outliers and cappings on the hills. Its average thickness, where best developed, is some 400 feet. The second area commences near Cape Riche, and stretches in a North-East direction beyond the Phillips River, thinning out Eastward to mere cappings on the hills.

The uppermost beds in the first-named area are generally more ferruginous than the lower, and consist of highly ferruginous concretionary claystone, shale, and grit.

The great denudation which has operated since the close of this period has removed a great portion of the rocks, leaving the remainder as undulating plateaus and flat-topped hills, at the bases of which the older rocks outcrop. As a rule these strata are horizontal, although in some cases a slight undulating dip is perceptible. The interstratified beds of white, yellow, and sometimes ferruginous limestone, attaining the thickness of 30 feet, which occur chiefly in the neighbourhood of Champion Bay, do not seem to be persistent, but are found, as it were, in patches, which gradually thin out.

As the limestone composing them is made up of shells, which in some cases have consolidated into a solid rock, in others have retained their original form, it seems most probable that the accumulation of shells in hollows, in ancient sea-beds, is the cause of their now being found in isolated areas. The most common fossils found included species belonging to the genera *Ammonitidæ*, *Belemnitidæ*, *Ostreidæ*, *Pectenidæ*, *Trigonidæ*, *Rhynchonellidæ*, etc. These fossils are generally found in the limestone, whole masses of rock being composed of them; they are also found in the hard ferruginous shale and sandstone, in which case they have been converted into oxide of iron. In a paper published in the proceedings of the Geological Society, the author, Mr. C. Moore, considers the fossils from these beds to represent the fossil fauna of the Lias and the Lower Oolitic formations of England.

The whole chalky limestone of Gingin, Yatheroo, and Dandarragan, which outcrops from beneath the sandy soil of these localities in patches, most likely is also of Mesozoic Age.

As yet, owing to the surface accumulations of sand, etc., which hides it from view, no sections are to be seen which show whether it overlies or underlies the ferruginous rocks of the district. At different spots in the Darling Range, etc., beds of ferruginous grit, claystone, and conglomerate exist together with beds of unconsolidated sand which may belong to this formation. Between Brookhampton and the Upper Blackwood Bridge near Coverley's, and elsewhere along the road, on the tops and slopes of the moderately steep ranges which occur there, there are deposits of soft earthy claystone and ironstone containing perfectly polished boulders of reddish sandstone, grit, and quartzite, varying in weight from a few ounces to 50 pounds, and of more or less spherical and elliptical shapes.

It is difficult to imagine how these boulders, which have evidently (judging by their waterworn condition, and the absence of any similar rocks *in situ* in the district) been transported a considerable distance, and now occupy the tops of ranges, could have been placed in their present conditions except by glacial action, if such were possible in this latitude. The outside of the pebbles and boulders are, whenever the rock is hard enough, smoothly polished, but as far as I am aware there are no striæ or scratches on them.

The second principal area of this formation, which embraces the country extending from near Cape Riche to beyond the Phillips River, consists of a series of horizontal sandstones, grits, and conglomerates, capped generally by the usual ferruginous claystones, the whole thinning out on to

the granite along its northern boundary at a level of from 600 to 700 feet above the sea, and forming level plains and table hills, with steep escarpments along the Gardiner, Fitzgerald, Hamersley, Phillips, and Jerdicart Rivers. To the Southward and Eastward the formation, which attains a thickness of some 300 or 400 feet, rises on the slaty rocks of the Mount Barren and Jerdicart country. In lithological and stratagraphical character and position they are almost precisely similar to the same formation in the more Northern parts of the Colony. White marly saliferous sandstones, ferruginous grits and claystones, conglomerate reddish sandstones, etc., are the principal rocks met with. Perfect specimens of fossil sponges are frequent in some of the caves which occur along the escarpments, hanging from the roof and sides, where the rock has weathered away; worm casts are also abundant. Mainbenup, near Esperance Bay, is the farthest point Eastward where I have observed the formation. At Cape Riche beds of white and mottled sandstone, overlying granite, form low but steep cliffs along the shore of the bay.

Since the above was written the Mesozoic beds have received further attention, and our knowledge in connection with them has been materially increased.

Boring operations have been carried out in these beds in the vicinity of Geraldton, where the strata have been proved to consist chiefly of sandstones, etc., which attain a thickness of at least 1,100 feet.

It is possible that to the former horizon the Coal Measures of the Collie River may belong.

The following fossils have been obtained from the Mesozoic Rocks of this Colony:—*Cristellaria cultrata*, Montfort, *var radiata*, Moore; *Rhynchonella variabilis*, Schloth; *Avicula Munsteri*, Goldf.; *Avicula echinata*, Sow.; *Avicula inæquivalvis*, Sow.; *Lima proboscidea*, Sow.; *Lima punctata*, Sow.; *Ostrea Marshii*, Sow.; *Pecten cinctus*, Sow.; *Pecten calvus*, Munster; *Pecten Greenoughiensis*, Moore; *Astarte Cliftoni*, Moore; *Astarte apicalis*, Moore; *Cucullæa oblonga*, Sow.; *Cucullæa inflata*, Moore; *Cucullæa semistrata*, Moore; *Cardium*, sp.; *Cypricardia*, sp.; *Gresslya donaciformis*, Ag.; *Isocardia*, sp.; *Myacites liassianis*, Quenst.; *Myacites Sanfordii*, Moore; *Tancredia*, sp.; *Trigonia Moorei*, Lycett; *Pholadomya ovulum*, L. Agass.; *Teredo Australis*, Moore; *Unicardium*, sp.; *Amberleya*, sp.; *Cerithium Greenoughiensis*, Moore; *Eulima* (?), sp.; *Phasianella*, sp.; *Trochus*, sp.; *Turbo Australis*, Moore; *Turbo laevigatus*, Sow.; *Rissoina Australis*, Moore; *Belemnites*, sp.; *Belemnites canaliculatus*, Schloth; *Nautilus perornatus*, Crick; *Nautilus sinuatus*, Clarke; *Ammonites (Dorsetensia) Clarkei*, Crick; *Ammonites (Stephanoceras) Australe*, Crick; *Ammonites (Sphaeroceras?) Woodwardi*, Crick; *Ammonites (Sphaeroceras) semiornatus*, Crick; *Ammonites (Perisphinctes) Championensis*, Crick; *Ammonites (Perisphinctes) robigonosus*; *Ammonites Aalensis*, *var Moorei*, Lycett; *Ammonites Walcottii*, Sow; Belemnites, sp.

Cainozoic Rocks.

The Cainozoic Rocks of the Colony occupy a very extensive area.

They are thus described by H. P. Woodward:—

EOCENE.

Coralline and Chalky Limestones with Flints.—The beds extend the whole length of the Great Australian Bight, and for 150 miles inland. They present a bold vertical face, of great height to the sea, evidently marking the line of a fault.

Coralline Limestones.—These form the lower beds of the coast limestone, and contain a great many fossils of Eocene age, some of which were sent to England a few years ago to be described. The beds at Sharks Bay, and on the islands there, are probably of the same age.

The Calcareous and Ferruginous Sandstones, Grits, and Conglomerates.—These beds are met with between the limestone hills, and the ranges probably belong to this older Tertiary Series, as well as the ferruginous conglomerates which rest unconformably upon the Cretaceous Rocks to the Southward of Champion Bay.

PLIOCENE.

"Pindan"—Cracked Plains.—These large sandy plains are greatly developed on either side of the Fitzroy River and stretch far away to the Southward, where they form Warburton's Great Sandy Desert. On the Ord River there are also some small stretches of country of this character, but nowhere of any very great extent. Owing to its porous nature these plains are waterless in spite of the heavy rainfall, nevertheless, as a rule, they are covered with abundance of vegetation.

Sand Plains.—These form one of the characteristic features of Western Australia, extending as they do from one end of the Colony to the other. The great sand plains of the interior are often 20 or 30 miles across, but since they contain, in places, a good deal of the clay and iron which cement the grains of sand together, so that, there being a fair rainfall, they are covered with hardy vegetation, which during the two spring months is perfectly gorgeous with flowers, and they form good summer grazing ground. These sand plains mostly appear to overlie the desert sandstone formation which forms the table-land of the interior of Australia.

Ferruginous Sandstones and Variegated Clays.—Plant remains are met with in these beds on the lower courses of the Gascoyne River, also at the Nullagine; and similar rocks without the plant remains, cap the low ranges in many places throughout the Colony. They are probably of Upper Tertiary age, although they may be still more recent. Beds, probably of this age, containing large quantities of fossil wood, and beds of brown coal, are also met with below the coastal sand plains of the South.

PLEISTOCENE.

Ancient river gravels and lake basins are found in several places in the ranges, and are similar in character to the deep leads of the Eastern colonies which proved so rich in gold. They consist of pipe-clay, ferruginous sands, gravel conglomerate, and mottled clay, and it is reported that Diprotodon bones have been found in one of these near Bridgetown, where these deposits are largely developed, and are now being worked for stream tin. Ancient river gravels are met with on the Nullagine and Ashburton goldfields, but, as a rule, they are not common in these districts.

Lower Estuarine Deposits.—These beds occur as far inland as Perth, where, in deepening the river channel, large quantities of oyster and other shells are met with, proving beyond a doubt, that the Swan was formerly a much larger arm of the sea than it is now. The oysters must have been exterminated by the silting up of the mouth of the river, which prevented the influx of salt water, keeping it fresh or brackish for a large part of the year. The deep holes in the bed of the Swan, to the West of Perth, prob-

ably owe their existence to the collapse of caverns eroded in the limestone which forms the bed of the river, by a subterranean flow of water containing carbonic acid.

Shelly Limestones and Sandstones.—These occur all along the South-Western coast, and contain fossils very similar to the living forms, upon which in many cases the nacre of the shell is still preserved. The shelly limestones and sandstones of Sharks Bay, and those met with here and there along the coast, as far North as North-West Cape, probably also belong to this series.

Recent.

Alluvium of Lake Basins.—Throughout the interior there is a series of what are called lakes, which are in reality nothing more than large salt flats, boggy marshes, or clay pans, almost on a dead level, that drain one into the other, and eventually, if the season has been wet enough, discharge themselves into the upper course of some river; but this rarely happens, owing to the enormous surface they present for evaporation. One result of this is that these large flats nearly every year receive a fine covering of clay, upon which the salts contained in the water crystallise out, to be redissolved and added to from time to time, till in some places, which may be a little lower than the rest, or where some obstruction occurs to check the flow of the water, very large deposits of salt accumulate. These lakes are surrounded by red clay flats which also contain a great deal of salt; in fact, the whole interior of the colony is salt, since the salts leached from the rocks are not carried away to the clay, to be redistributed over the surface of the country by the wind.

Salt and Gypsum Deposits.—Many of the lake basins are covered by deposits of salt and gypsum, the latter often occurring in the form of beautiful crystals (selenite).

River Valleys.—Loam deposits are formed by the rivers wearing away the old rocks, and carrying the finer material down from the hills and depositing it on the open level country, where it forms large rich plains. These deposits are often of great extent, spreading on either side from the rivers for a considerable distance. They are often very similar in character to those of the lake basins, but with this great difference, they contain less salt. They are best studied on the Upper Murchison, the Gascoyne, or Fitzroy Rivers, where there are large clay and loam flats, often many miles wide. These beds have probably been formed in the same manner as those of the lakes; but, having been better drained, the salt has been carried away by the rivers. Certain tracts, however, still contain much salt, which is replenished from time to time by large discharges of salt flood water from the lakes at the sources of the rivers. All the rivers North of the Greenough form these large flats, but those in the South form, instead, small deposits of clay, loam, sand, and gravel throughout their courses, which are very fertile.

River Gravels.—These consist of sand, gravel, and angular fragments of rock, and are found in the beds of the Northern streams, where large rivers are often as much as a mile wide. In the North there are some extensive alluvial deposits, following the sea coast, not generally situated in the river valleys themselves, but formed by the rivers in time of flood; they are not, as a rule, of any great thickness, because outcrops of rocks are frequent.

Brick Earth.—These deposits are met with in the valleys of many of the Southern rivers. They are of high quality, making excellent terra cotta ware, drain pipes, and bricks.

Estuarine Deposits.—These are met with at the mouths of the large Northern rivers, where there are periodical tropical and semi-tropical floods. The rivers bring down large quantities of mud, which they deposit near

their mouths, forming (excepting where coastal currents interfere) a kind of swampy delta, for the most part salt, overgrown with mangroves, and composed of a black, greasy mud, full in many places of recent petrifactions of crayfish, wood, and worm-tubes. The estuarine deposits of the South are of very slight account, for the rivers are comparatively small, having but short courses, and discharge themselves, on emerging from the gorges they have cut through the ranges, into the arms of the sea, which runs from the coast to the foot of the ranges. Moreover, they are but seldom flooded by excessive rainfall, and so bring down very little detritus.

Mangrove Swamps.—Black, muddy, salt swamps, covered with mangrove, fringe a great part of the coast North of North-West Cape, or that part where the tide has considerable rise and fall. They are situated just about high-water mark, and are therefore covered either by each high tide or only by the spring tides. Sand dunes occur along the West and South coasts at the river mouths, or where the land is low. They sometimes, as at Geraldton, reach a considerable height, and are a source of trouble, because they are constantly travelling unless kept carefully bushed or planted. Very often excellent water can be obtained beneath them, although that under the neighbouring flats may be bad.

Coastal Sand Plains.—These plains are met with in the Southern portion of the Colony, extending from the foot of the ranges, and cover the intervening lower ground between them and the sea. The sand here is much looser than in the interior, and is often of considerable thickness, of a red colour below the surface, and exhibits false bedding, which proves its origin to be Eolian or windblown. There are many lakes and swamps on the plains, the water in which is often held by deposits of peat.

Raised Beaches.—These were noticed by the late Mr. Hardman near Roebuck Bay, about 10 to 15 feet above the present sea level. One extends nearly 25 miles inland, and is from 12 to 18 miles wide. Its surface is covered with salt grass and samphire. Recent marine shells are found here and there, and in sinking a well a shelly deposit several feet in thickness, containing specimens of sea shells now found living on the coast, was passed through. Raised beaches of considerable extent are also met with at the foot of the Great Australian Bight.

Marine Shell Marls and Gravel.—These are of frequent occurrence along the coast between North-West Cape and the Leeuwin.

Surface Deposits.—Under this head come a large series of deposits not already referred to, the principal of which are the "gravel" and "ironstone," which cover a considerable extent of the South-Western portion of the Colony. These deposits are in reality indurated, nodular, ferruginous claystones called gravel, sometimes cemented by iron forming a conglomerate, and ferruginous sandstones, both of the latter being locally known as ironstone. They result from the disintegration of the different underlying formations (mostly crystalline rocks), and are most largely developed in the forest ranges, and it is upon them that the best jarrah grows. The so-called gravels are often of considerable thickness, and are largely used for ballasting railway lines. Their origin is difficult to understand, without it is due to bush fires, as they cap the highest ridges up to an elevation of 1,200 feet.

Volcanic Rocks.

Volcanic Rocks, claimed as being of Devonian Age, have been described by E. T. Hardman, from the Kimberley District :—

They consist of many varieties of basalt, including dolerite, and amanesite, trachy-dolerites, lavas, volcanic breccias, and ash beds, ferru-

ginous wackenite, etc., and . . . . occupy a very extensive area of the country to the East of the Ord. The basaltic rocks not only occupy a considerable superficial area, but they are also of considerable thickness. . . . . This formation occurs as a vast sheet or floor of volcanic rocks, which was formerly ejected and spread out over the Devonian Rocks, and subsequently in part denuded, and then covered by the Carboniferous deposits, and these in their turn being to a great extent carried away, the basalt has again been exposed over the extensive area where we now find it. That it is of an intermediate age between the Carboniferous and the supposed Devonian Rocks is certain, for within a short distance it is found resting on the one and covered by the rocks of the other formation, as at the junction (and a few miles below it) of the Panton and Elvire.

In the Ord District these rocks form a great plateau, as hereinbefore described. As a rule they show a distinct bedding, the lines of which dip inwards to the mountains at angles from 5 to 10 degrees. The traps are extremely varied in character; although they may be regarded as the same rock as a whole, still in the same neighbourhood many varieties of specimens can be obtained.

Ancient lavas and breccias are common amongst these rocks, and some of the latter would seem to have been deposited under water, as they are distinctly stratified. Volcanic ash or tufas, consisting of fragments of basalt, trachy-dolerite, lavas, etc., are met with also. In one locality, near Mt. Napier, the deposit contained large angular fragments of the easily-recognisable Devonian grits; the nearest place where such rocks are at present found being 40 miles distant. These fragmental deposits were, however, probably found not far from some ancient volcanic vent. No indications of such volcanoes were actually observed; but there are many high peaks and cones visible across the plateau, some of which may prove, on more careful examination than we were able to give, to be portions at least of the ancient craters. At the same time the country has been subjected to such a vast amount of denudation that it is only barely possible that any of them should retain their original form.

Ferruginous Wackenite, or "Wackenite Dolerite," is a rock which caps the summit of Mt. Napier. It is deep red in colour and somewhat columnar in structure. When broken into it appears like a mass of somewhat pebbly red hematite, but it is simply the result of the gradual decomposition of the basalt which forms this hill. This Wackenite cap is 20 or 25 feet thick.

Other basaltic rocks of undetermined age occur in the same neighbourhood; there are, however, very good reasons for believing that they belong to the same geological period as those last described. Mr. E. T. Hardman thus describes these rocks:—

Along the Western and Southern extremity of the Leopold Ranges a band of trap rock, about a quarter to half a mile in width, occurs. It has been traced from Mt. Phillip to Mt. Huxley, and is again seen in a deep gorge, which apparently cuts right through these hills, passing a quarter of a mile North of Mt. Huxley and continuing in an East-South-Easterly direction for about four miles. This chasm, which was named Straith-na-diaoul, is cut through quartzites and altered grits to the underlying trap rocks, which are about 500 yards wide; and these, as well as the band outside the range, have evidently been forced up long after the stratified rocks were deposited, as may be inferred from the manner in which those stratified rocks have been contorted and tossed about in the immediate vicinity of the traps. Here the traps pass from diorites into dolerites, and *vice versa*. Similar rocks are seen at the upper end of the gorge through which the Margaret passes, at J 11, where these basaltic rocks are seen in the river bed, and in the precipitous river walls for more than one and a-half

miles, and in places for more than a quarter of a mile in width. That this basaltic outburst is of later date than that of the overlying rocks is certain as the latter, which belong to the Metamorphic or Lower Silurian (?) system are upheaved by it to a considerable height and greatly contorted in places.

The character of the basalt here is similar in every respect to that near Mt. Huxley, and also to that of the flow basalts of the Antrim plateau. It is highly crystalline in places, and contains large quantities of olivine and epidote, with quartz veins.

Basaltic lavas are also known on the North-West coast to the South of Nullagine, and also on the Fortescue River.

Between Lake Cowan and Widgiemooltha the character of the country, according to the researches of S. Göczel, late Field Geologist, is such that:—

All circumstances point out that the diorites in this place are the remains of lava streams which have flowed from a volcanic centre situated between the Lakes Lefroy and Cowan, and to which also the formations of a watershed between the two lakes is due.

The same writer also states that:—

Lake Cowan occupies the depressions of an old volcanic region. . . . Nearly all the surrounding country of that lake consists of amphibolites, old greenstones, felsitic rocks and tuffs. The North-Western shore is approached by gneiss-granite hills, often covered with amphibolites or greenstone cappings. The Palæozoic volcanic rocks become more and more predominant as we approach towards the lake, beneath which the gneiss-granite completely disappears. Along the Western shore of the lake the great break in the Archæan strata is most pronounced, and the rugged mountains and hills extending along the shores and forming islands in the lake are ruins of old volcanoes, which in their time were of similar build to the strata volcanoes of later periods.*

Basaltic lava is also known at Bunbury: here a mass of columnar basalt rises about 20 feet above sea level. Similar basalt again makes its appearance about five miles to the South of the Capel River. Basalt has also been described as occurring on the South Coast, to the East of Flinders Bay, at Black Point.

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* "Geological Notes and Sketches." S. Göczel. Appendix vi. *Ad interim* Report on the Department of Mines for the half-year ending 30th June, 1894. Perth: By Authority, 1894; pp. 36 *et seq.*

CHAPTER II.

GOLD.

General.—Gold Matrices, Associated Minerals, Purity of Western Australian Gold. Kimberley, Pilbarra, West Pilbarra, Ashburton, Gascoyne, Peak Hill, Murchison, and East Murchison Goldfields.

General.—The auriferous deposits of Western Australia have been responsible for the 4,127,374 ounces of gold, valued at £15,684,022, which have been exported. The relations which these deposits, one of the factors of the Colony's prosperity, bear to the broader geological features, naturally take a prominent place in any account dealing with its mineral resources. The method adopted in dealing with the auriferous deposits is to describe each goldfield separately, giving a brief *aperçu* of its salient features, although the information available for this purpose is, in one or two cases, much more fragmentary than could be wished. It has been found most convenient to adhere to a strictly geographical order in description, beginning with the field at the Northern extremity of the Colony. The description of each field is followed by a table, giving the yield of gold as shown by (*a*) the figures furnished to the Department of Mines; and by (*b*) the data in the archives of H.M. Customs House. It will be noticed that in all cases there is a difference between the two sets of figures. Up to the end of 1899 there have been officially reported to the Mines Department 3,850,332 ounces of gold from the various fields of the Colony; the Customs authorities, however, give 4,127,374 ounces as that entered for export, being 277,042 ounces in excess of the figures furnished to the Mines Department. The discrepancy is to be accounted for by the difficulty experienced in obtaining a record of the alluvial gold, and also by the fact that a good deal of the gold won in the early days was probably never officially reported. Writing in 1899, the Warden of Yilgarn notes, with reference to the output of gold from that district, that "a good deal of gold leaves the field and is not recorded." *

As alluded to in the previous chapter, the crystalline rocks—the matrices of the auriferous deposits—are divided into three broad parallel belts, formed of granite, gneiss, and schist, which trend generally North-West and South-East. Observations have

* Report of the Department of Mines for the year 1898. Perth: By Authority: 1899; p. LXXV.

shown that there are two fairly well defined, and more or less continuous ore-bearing belts which have a distinct relation to the geotectonic features of the crystalline rocks. The schists which constitute the principal auriferous belts form long and comparatively narrow bands or attenuated elliptical patches. The schists consist of mica, chlorite, sericite, hornblende, and quartz, and serpentinous schists together with hematite-bearing quartzites.

All the important auriferous areas occur within the limits, or in the immediate vicinity of country occupied by the schistose rocks. These auriferous belts occupy a very large area of country, extending from the South Coast to the country lying between Spit Point and Cape Lambert, on the North-West Coast, extending over about 14 degrees of latitude. The auriferous belts exceed twenty miles in width in places. There is a larger area of auriferous country exposed at the surface than in any other portion of Australasia.

At my request the Mineralogist and Assayer has furnished the following brief account of the gold matrices, so far as can be judged by work in the laboratory; as far as possible his own words have been adhered to, though some slight condensation has been made in certain places.

Gold Matrices.—Over the area occupied by the auriferous schistose rocks, the ore deposits fall naturally into two broad divisions.

(*a*.) Lodes and other deposits in which the concentration of the precious metal has been subsequent to the formation of the enclosing rock.

(*b*.) Original alluvial deposits in which the gold has been concentrated by mechanical action contemporaneously with the formation of the rock itself.

The deposits included in Class *A* may be further sub-divided into (1) veins, including stockworks; (2) dykes; (3) deep-reaching impregnations of zones of rock; (4) shallow impregnations of surface material. They are found chiefly in amphibolites and hornblende schists, but chloritic schists of somewhat doubtful origin frequently constitute the enclosing rocks mass, and in the Northern parts of the Colony mica schists, slates, and quartzites or sandstones are also found as matrices.

(1.) *Veins.*—The gangue material of most of these is quartz, but other minerals in places largely replace it, as, for instance, dolomite and other carbonates at Red Hill, Coolgardie Goldfield, and Vosperton. The quartz reefs of Coolgardie, Norseman, Southern Cross, Menzies, Cue, Wiluna, Salgash, Mt. Magnet, and Ruby Creek has been largely responsible for a very considerable proportion of the total production of gold from those districts, but at other centres, such as Kalgoorlie and Kanowna, have been of minor importance. The quartz of these veins in the Southern and

Central portions of the Colony is usually milky white, but further North is frequently transparent and of a bluish tinge. Stockworks of quartz veins in felsite or other dyke rocks have yielded payable gold in Coolgardie, Bardoc, and Kalgoorlie, whilst fault-breccias, which form the connecting link between this and the third class, have been worked in Coolgardie, Menzies, and Mt. Magnet.

(2.) *Dykes* of felsite and acid porphyries associated with the older basic schists are occasionally found to carry a considerable quantity of gold, both in the solid rock and in the quartz stockworks which it encloses. Instances of this form of deposit are to be found at Londonderry, Burbanks, and Bardoc.

(3.) *Impregnations of Zones of Rock.*—These form the most interesting and possibly the most important source of the precious metal in Western Australia. They consist of bands of much fissured rocks merging insensibly into more solid rock of similar origin and constitution on both sides. They are both known to the miners as "lode formations." Being merely portions of a large mass of rock, which in consequence of dynamical agencies has permitted of the free circulation and subsequent deposition of mineral solutions, these deposits are characterised by having no well-defined walls, the limits of the deposit being determined by the decrease in the assay value of the rock to a point at which it ceases to pay the expenses of working. The most notable development of deposits of this description is to be found at Kalgoorlie, from which, from 1895 to 1899, something like one and a-half million ounces of gold have been extracted. In this area the chief rock developed is a chloritic schist, which may be an acid porphyry now highly foliated and otherwise altered. A similar rock occurs under like conditions, and is auriferous, at Kanowna, whilst at Peak Hill a notable amount of gold is derived from quartz schists and other foliated rocks. At Mount Leonora and at Norseman, especially the former, similar deposits have also yielded payable ore. To this class are to be referred the ore bands of chalcedonic quartz and jasperoid rocks which are of such frequent occurrence in the Colony, and which contain payable gold in such widely separated localities as Black Flag, Mount Magnet, and Horseshoe. Bands of rock, generally more or less foliated, are frequently found to be auriferous in close proximity to rich quartz reefs. Gold is thus found in serpentine schist and amphibolite at Coolgardie, in amphibolite at Bardoc, in sandstone at Donnybrook, and slate in the Kimberley district.

The auriferous conglomerate beds of Nullagine are also to be referred to this class, the gold in them being of secondary nature, and occurring in somewhat well defined bands.

(4.) *Shallow Impregnations of Surface Material.*—The upper portions of the old rock surface immediately underlying the richer leads at Kanowna have been found to contain payable gold in many places, and have been worked out with the latter. The rock consists of decomposed porphyry and chloritic schists, and most if not

all of the gold in it is in the form of fine scales on the cleavage planes, showing that the enrichment of the stone with the gold has been largely subsequent to weathering of the rock. The so-called "pug" of Kanowna, a bedded kaolin of comparatively recent age overlying the coarser auriferous wash, is externally rich in places owing to the large development of crystalline and leaf gold in its cleavage planes. This is probably a further example of this class which is found to pass imperceptibly into the true original alluvial deposits.

The deposits included in Class *B* comprise (1.) residuary soils and gravels; and (2.) alluvial deposits.

(1.) *Residuary Soils and Gravels.*—In such districts as Kalgoorlie, where the rainfall is very slight, and where rich gold-bearing rocks outcrop frequently on comparatively flat ground, the surface soil resulting from the decomposition *in situ* of these rocks is highly auriferous, a natural cause of concentration being the removal of the lighter portions of the soil by the wind. Much of the surface gold of Western Australia has been derived from deposits of this nature, especially at Boulder and Coolgardie, where much of the alluvial of Fly Flat, at least, was merely the decomposed residue of auriferous felsite dykes. These residuary deposits pass insensibly into :—

(2.) *Alluvial Deposits.*—These may be roughly divided into recent accumulations still in process of formation, and older deposits no longer being enriched by the addition of fresh gold-bearing material. Examples of the former are to be found in every district where reef gold is being obtained, and, in the interior of the Colony where the rainfall is small, are never at any great distance from the parent ore body. The material of which these deposits are composed is generally a more or less ferruginous sandy clay, frequently carrying much travertine. Of this nature are the more recent deposits of Bardoc, Kalgoorlie, and Coolgardie. On the Pilbarra and other Northern fields, where the rainfall at certain seasons is very heavy, a considerable quantity of gold is recovered from the river sands and gravels of the usual nature. The dry lakes of the interior, occupying as they do the lowest lying portions of the country, have long been suspected of containing in their sandy beds material which would pay to treat on a large scale. The last division of gold deposits embraces those older alluviums which have, so far, only been worked in six places, viz., Kanowna, Bulong, Broad Arrow, Kalgoorlie, Kintore, and The Island, Lake Austin. At Kintore (Coolgardie Goldfield) the gold occurs in a series of beds of sandstone, conglomerate, and kaolin, forming the remnants of an old river deposit on a granite bedrock. At Kanowna, the deposits are of two distinct ages, (1) the older siliceous conglomerate ("cement") outcropping at the surface, and now quite vitreous from the development of secondary silica; (2) the newer deposits of the deep-leads, consisting of a series of sands, gravels, clays, magnesia, travertine, vitreous sandstone, and conglomerate, all of which carry payable gold.

Associated Minerals.—Of the metallic minerals which are found to accompany gold in Western Australia, by far the most important is iron pyrites, which, with its concomitant oxides of iron, is found in every ore body from Kimberley to Dundas. Not only is this mineral found in close conjunction with free gold, but in many instances, such as at Red Hill (Coolgardie Goldfield), is found itself to carry a considerable amount of gold imperceptible to the naked eye. As a rule, the pyrites does not constitute more than four or five per cent. of the gangue, but at some mines in Menzies and Mt. Ida, amongst other places, it forms one-half or more of the latter.

Next in order of importance after pyrites is galena. It occurs in the gold reefs of Hall's Creek, Brockman's, and all the other Kimberley centres; but it is found that the richer the stone in galena the poorer in gold. Galena also occurs in conjunction with gold at Tambourah and Horseshoe.

Vanadinite has been detected with gold at Coolgardie and Pinyalling.

Arsenopyrite accompanies gold at Ruby Creek, Niagara, and Coolgardie. Some beautiful specimens of this mineral have been obtained from Bayley's United Gold Mine at Coolgardie. They consist of veined arsenopyrite traversed in every direction by a network of veins of gold, varying in width from 1-20th of an inch down to a microscopic thickness.

Zinc Blende is an indication of rich ore at Yandicoogina, Coolgardie, and Lawlers; in each instance, however, forming a very small proportion only of the total gangue.

Native bismuth and bismutite are found in auriferous quartz at Burbanks, Dundas, Yalgoo, and Lawlers. At Burbanks the native bismuth is alloyed with gold to the extent of about one per cent. The bismuth at Lawlers is also, in all probability, alloyed with gold, since the surrounding scales of bismutite are thick with fine scales of metallic gold.

Pyrrhotite occurs in the quartz reefs of Southern Cross and Burbanks; in neither of which instances is it nickeliferous.

Chalcopyrite and copper carbonates occur in association with gold at Coolgardie, Sir Samuel, Tambourah, Hall's Creek, Gorge Creek, and many of the Murchison centres.

Bournonite is of frequent occurrence in the beds at Kalgoorlie, and is also said to accompany gold at Wiluna.

Native copper is reported from Coolgardie, Sir Samuel, and Roebourne.

Scheelite occurs in bunches in auriferous reefs at Coolgardie and Southern Cross, but in both instances is characteristic of poor ore.

Exceptional occurrences are those of Calverite, Coloradoite, Kalgoorlite, and other tellurides together with Bournonite and Löllingite in the Kalgoorlie ores, and of Native Silver in auriferous quartz at Nannine. So too, is that of Asbolite rich in cobalt and carrying freely visible gold at Kanowna.

Of the earthy secondary minerals which accompany gold in Western Australia quartz is the most important here as elsewhere. Gold occurs in veins of calcite, more or less magnesian, at Mary River, Panton River, Kalgoorlie, Kanowna, and Red Hill (Coolgardie Goldfield). Chalcedony occurs in many quartz veins, and is characteristic of much of the better ore at Donnybrook. Gold has been found in gypsum at The Island, Lake Austin, and is of frequent occurrence in the oxidised zone at Kalgoorlie. Actinolite, chlorite, and other minerals derived from the enclosing rock mass are found in many quartz reefs, but probably owe their origin to agencies other than those which caused the deposition of the gold, and are for that reason of little interest.

Purity of Western Australian Gold.

In order to calculate the value of the exports of the Colony, the Customs authorities have assumed an average value of £3 16s. per ounce, or a fineness of 894·7 for all the gold bullion turned out by the various mines. Seeing however that the purity of this bullion depends not only on the purity of the metal in the ore, but also upon the nature of the other minerals in it, the method of extraction, and the degree to which the refining process is pushed at the mine, this factor gives but little idea of the original fineness of the metal.

No analyses of the native metal from Western Australia would appear to have ever been published, but the following few figures were obtained in the laboratory of the Geological Survey at Perth:—

No.	Nature of Gold.	Locality.	Specific Gravity	Gold.	Silver.	Copper and Iron.
1	Small alluvial nuggets	Hall's Creek, Kimberley Goldfield	16·62	933·0	66·0	1·0
2	3oz. alluvial nugget carrying quartz	Do.	16·80	883·9	116·1	?
3	"Bobby Dazzler" quartz nugget	Shark's Gully, Pilbarra Goldfield	14·66	768·1	230·4	1·5
4	Gold from quartz boulders	Talga, Pilbarra Goldfield	16·20	844·6	155·4	?
5	Gold from quartz reef	Peak Hill, Peak Hill Goldfield	17·16	965·4	34·6	
6	Coarse gold in quartz reef	Nannine, Murchison Goldfield	15·75	894·5	105·0	·5
7	Crystalline gold from calcite vein	Red Hill, Coolgardie Goldfield	18·00	932·1	67·2	·7
8	Gold from conglomerate bed	Nullagine, Pilbarra Goldfield	...	912·1	87·9	
9	Coarse gold from ironstone pebbles	Block 50, Hampton Plains	18·91	994·6	6·4	Trace

The last analysis is of special interest as this gold appears to be the purest on record, except that from Mt. Morgan, Queensland.

THE GOLDFIELDS.

Kimberley Goldfield.

The most Northerly goldfield in the Colony is that of Kimberley, which was discovered in 1882 by Mr. E. T. Hardman, then Government Geologist.

The goldfield, which embraces an area of about 47,600 square miles, was proclaimed on the 20th May, 1886. The boundaries, as defined by the authorities, are as follows:—

Bounded on the North by the 16th parallel of South latitude; on the South by the Southern boundary of the Kimberley District (latitude 19° 30′ South); on the West by the 126th Meridian of East longitude; and on the East by the Eastern boundary of the Colony (longitude 129° East).

The strata exposed on the goldfield consist of crystalline schists of Archæan age, together with representatives of Cambrian, Devonian, and Carboniferous rocks, as well as a large development of volcanic rocks.

The *Carboniferous Rocks* of Kimberley occupy a very large extent of country, and have been estimated to cover an area of about 2,000 square miles.

The beds, which attain a maximum thickness of about 2,500 feet, are said to owe their preservation to a well-marked fault which trends North-West and South-East. The rocks consist of sandstones, grits, and conglomerates, with limestones and sandy shales. The strata lie practically horizontally. The calcareous beds of the Lower Series form bold precipitous escarpments, such as those in the Geikie, and the Napier Ranges. The formation has yielded a suite of Carboniferous fossils.

The *Devonian Rocks* of Kimberley occupy an extensive area of country; they are seen to rest directly upon older rocks, and to be covered by basaltic lavas which are overlaid by beds containing Carboniferous fossils. The beds consist of almost horizontally-bedded hard, grey, red, or green grits and conglomerates, associated with highly indurated limestones and shales. The formation attains a maximum thickness of about 1,000 feet, and has proved to be fossiliferous.

Cambrian Rocks have been identified by palæontological evidence from certain portions of the district. The beds consist of highly inclined crystalline limestones, sandstones, grits, quartzites, clay slates, etc., and have yielded *Salterella Hardmani*, and *Olenellus* (?) *Forresti*. This formation is of considerable economic importance, in that it is amongst these beds that the principal gold deposits have been discovered. So far as present observations have been carried, the formation extends in a North-East and South-West direction, from the Burt Range to the South of Mt. Dockrell.

The beds have been folded in such a manner that the principal axes trend North-East and South-West. No observations have as yet been made with the view of determining the thickness of the formation.

The *Crystalline Schists* and allied rocks are highly developed in Kimberley. They consist of micaceous and talcose schists, gneiss, and granite. They have been proved to extend from near Denham River to Mount Dockrell, and appear again in the Mueller Range, a little further West, and striking North-Westwards pass through the King Leopold Range to King's Sound. This belt of rocks varies in width from 10 to 30 miles, and has been proved to have a horizontal extent of at least 120 miles. The crystalline schists have been folded in a North-West and South-East direction, with a secondary folding in a direction approximately at right angles to this.

Mining operations on the Kimberley field have been chiefly confined to six principal centres, viz., The Panton, Hall's Creek (the official centre of the field), Brockman's, Ruby Creek, The Mary River, and Mount Dockrell.

Up to the end of 1899, the Kimberley field has yielded, according to the Mines Department figures, 14,320ozs. of gold; the Customs authorities, however, report that up to the same date 25,029ozs. have been entered for export. There is thus a discrepancy of 10,709ozs. between the two different sets of figures. This difference may in all probability represent the yield of alluvial gold, which, unless under exceptional circumstances, is never reported to the Government.

Writing in 1895, Mr. E. T. Hardman thus refers to the Quartz Reefs of Kimberley:—

. . . Quartz reefs and veins are very numerous, but most especially so in the gneissose and schistose rocks. In the granites below the Leopold Ranges they are not very abundant, although often noticeable. Here they strike usually East and West, or a little to the North of West; but in all the metamorphic rocks to the Eastward they are found plentifully. In many places these quartz veins look to be promising for metals, and often contain quantities of black iron sand, iron pyrites, etc. They vary in thickness from one to eight feet. The schistose country, stretching from the McClintock Ranges to the North-North-East, is traversed by an enormous number of quartz reefs. In some localities many of these occur in the space of a few hundred yards, and it was quite usual to notice 25 or 30 large reefs, veins, or strings. The quartz constituting these reefs is of a very favourable character. It is a dull, yellowish and grey quartz, very cellular and ruggy, containing quantities of black and other oxides of iron, together with casts of, and often crystals of, iron pyrites. From most of the surface quartz the enclosed minerals have been washed away, however, although their traces are still apparent. Minute specks of gold have been noticed in a few cases, and I have very little doubt that many of these reefs, when properly examined and tested, will prove to be auriferous. The quartz reefs in this part of the country have a bearing of North 10 degrees West to North-East; many run due North and South; some of them can be traced for many miles.*

* The Geology of the Kimberley district. E. T. Hardman, Perth: By Authority: 1885; p. 22.

At the Panton River there would seem to be two series of reefs, the first of which, striking North-East and South-West, consists of true veins. Although small in size, they can be traced for a considerable distance at the surface, and it is on this series that most of the claims were taken up. The second series appear at the surface as large quartz blows, striking East and West, cutting across the smaller veins, but they cannot be traced for any distance at the surface, and, up to the present, gold has only been found in one reef at the extreme Western edge of the field, close to the Mackintosh Hills. *

Yield of Kimberley Goldfield.

Year.	Ore crushed.			Yield of Gold therefrom.			Gold exported.			Remarks.
	tons.	cwt.	qrs.	ozs.	dwts.	grs.	ozs.	dwts.	grs.	
1886							302	0	0	
1887							4,873	0	0	
1888							3,493	0	0	
1889							2,464	0	0	
1890							4,474	0	0	
1891	*a* 13,199	10	0	12,733	19	23	2,699	12	8	*a* Details not available.
1892							1,088	16	22	
1893							1,621	13	23	
1894							588	12	17	
1895							876	13	16	
1896							891	17	6	
1897	383	10	0	229	6	0	554	1	12	
1898	175	0	0	*b* 440	3	10	287	17	17	*b* Inclusive of 310ozs. of alluvial.
1899	694	0	0	*c* 917	3	0	814	7	6	*c* Includes 417ozs. of alluvial.
Total	**14,452**	**0**	**0**	**14,320**	**12**	**9**	**25,029**	**13**	**7**	

Pilbarra Goldfield.

The Pilbarra Goldfield was proclaimed on the 19th September, 1895; it embraces an area of 35,100 square miles.

Its boundaries, as defined by the authorities, are as follows:—

Bounded by a line starting from a point on the Sea coast Eastward from Condon Creek and extending through the summit of Poolingerena (or Mount Blaze) to a spot due North from the summit of Mount Macpherson; then South through the said summit to a spot due East from the summit from Mount Marsh, on the upper Fortescue River; thence due West through the summit of Mount Marsh to the right bank of the Fortescue River, along it downwards to Survey Station V23; thence in a Northerly direction through Survey Station V32 to the right bank of the Cocreaca branch of the Yule River, and along the right bank of the Cocreaca Creek and the Yule River downwards to the Sea coast, and along the Sea coast Eastward to the starting point.

Very little is known with reference to the geology of the Pilbarra goldfield, for with the exception of a hurried visit by the ex-Government Geologist some years ago, no official examination of the district has been made.

* Mining Handbook to the Colony of Western Australia. H. P. Woodward Perth. By Authority: 1895; p. 74.

So far as observations have at present been carried, it would seem that a large portion of the goldfield consists of granite and other crystalline rocks, intersected with dykes of diorite, and associated with slates, sandstones, limestones, quartzites and conglomerates. There seems to be an upper horizontally-bedded series of strata, resting upon crystalline rocks, across the strike of which several large rivers have cut their channels. The superficial area, or thickness of these strata, and their structural relationship have not yet been worked out, hence our information in connection with them is much more meagre than could be desired.

There are six principal mining centres on the goldfield, viz., Bamboo Creek, Talga Talga, Nullagine, Marble Bar, the Shaw, and Tambourah.

Bamboo Creek consists of granite and granitic gneiss (foliated granite?) striking North-East, and associated with quartzites and diorite dykes. The quartz reefs, said to be small where exposed on the surface, widen out in depth; in one instance, in the "Bulletin" Mine, the reef attains a thickness of as much as 10 to 12 feet. The quartz is associated with ores of iron, copper, lead, and manganese.

The rocks in the vicinity of Talga Talga consist of diorite, quartzite, and Jaspideous rocks. The quartzites trend slightly to the East of North, and underlie at a high angle to the Westward. The qnartz reefs are said to be well defined, and associated with ores of iron, copper, and manganese.

The mining centre of Nullagine is situated about 180 miles South-South-East of Condon, and 300 miles East-South-East of Roebourne.

The staple formation in the vicinity of Nullagine consists of grits, slates, sandstones, and conglomerates, striking North-East, and dipping at low angles to the North-West. Flat table-topped hills of conglomerate and cement occur in the vicinity; these beds are newer than the slates and other associated rocks referred to. Underlying the cement, much of which is either a compact body of ironstone conglomerate or nearly pure hematite, is a deposit of kaolin from 10 feet to 50 feet in thickness. This conglomerate, some portions of which are very vesicular, has been successfully worked for the gold it contains: crushings from the outcrops have yielded as much as 2ozs. to 4ozs. of gold to the ton. The conglomerate occurs in ranges which rise to about 100 to 150 feet above the level of the surrounding country.

The hills . . . . . upon which the chief mine workings are at present situated, appear to be mostly round-backed and strewn with rounded boulders and pebbles. On closer examination one finds that they consist of bed upon bed of conglomerate, merging into intermediate layers of kaolin. The beds dip universally to the North-West and strike North-East and South-West. The dip is flat, averaging perhaps 15 degrees. Therefore, as one approaches from the South-East the hillsides exhibit longitudinal sections of the country, and in some cross-gorges very complete studies may be made of cross-sections, whilst, where the rounded weathered hillsides slope to the flat, one may notice somewhat regular lines of round boulders and pebbles roughly marking the outcrops of the conglomerate beds. By these

indications, and also by following up the runs of alluvial gold until they stopped all along certain horizontal lines, the auriferous conglomerates were originally located and worked by prospectors by means of drifts and tunnels. Some of the conglomerate beds contain boulders up to three or four feet in diameter, while others carry nothing bigger than a man's head. These boulders consist of rounded masses of quartz, traprocks, and other conglomerates. A peculiar feature about the shape of these is that they are very often somewhat flattened like curling-stones.*

Some samples of the auriferous conglomerate have been examined in the Survey Laboratory, and have been thus described:—

A specimen typical of the finer grained portions of the rock in its upper decomposed portions. It consists of sub-angular fragments of quartz, ironstone and shale, cemented together by ironstained kaolin, containing numerous cuboidal cavities at one time filled by pyrites crystals, as shown by the numerous pseudomorphs of limonite contained by them. There are several much weathered volcanic bombs embedded in the rock. It assays 1oz. 6dwts. of gold, for which metal it is treated on a large scale by the battery amalgamation process. A similar but less ferruginous variety showed no cavities vacated by pyrites and is much coarser in grain, some of the fragments of quartz being 3 inches in length. It assays 2ozs. 1dwt. of gold per ton.

Another variety made up of large pieces of felstone, with smaller fragments of quartz, imbedded in a kaolinic matrix, assayed 10dwts. of fine gold, and 5ozs. 4dwts. of coarse gold per ton.†

In some respects this auriferous conglomerate bears a close resemblance to those auriferous conglomerates of the Rand, better known perhaps as Banket deposits.

In the vicinity of Nullagine are a series of older slaty rocks, which dip to the North-West at a low angle, and which have proved of importance in that they form the matrix of numerous auriferous quartz reefs and leaders.

The main reefs, however, run with the country, striking North-East. The surface is strewn with their *débris*, and dry-blowers have gathered good harvests therefrom. About three years ago attention was attracted to the reefs themselves by the discovery of several very rich patches of stone on their outcrops, and since then a considerable amount of mining has been done and many good crushings have been taken out. The character of the quartz in the big reefs is mostly very white and vitreous, and in this kind of stone the gold is generally coarse and occurs in bunches; while in smaller reefs, and sometimes in certain splices of the big ones, a more kindly-natured stone is found, showing perhaps fine gold and prospecting well all through.‡

Alluvial workings of three classes occur:—1st, the alluvium of existing creeks; 2nd, the alluvium of older creek beds, but in conjunction with the present streams; 3rd, old alluvial deposits or deep-leads bearing no relation to existing streams or configuration of the country. The most recent deposits are easily worked, for Nature is at work here to-day ground sluicing *débris* from the older formations, therefore no sinking is required, and the dirt is so free that it can easily be dry-blown. The older alluvial deposits are found in the river flats, where auriferous gutters are crossed

* The Nullagine District, Pilbarra Goldfield, Western Australia. S. J. Becher. Trans. Inst. M.E. (Newcastle) Vol. XVI, Pt. 1, 1898; pp. 48-9.

† Annual Progress Report of the Geological Survey for the year 1897. Perth: By Authority: 1898; p. 48.

‡ S. J. Becher. *Loc. Cit.*

and recrossed by the present streams. The sinking here is about 10 feet, and very hard work, owing to the fact that the deposits that overlay the dirt are cemented masses of quartz and boulders of other hard rocks.

The deep leads are cut across by the present valleys, and can be traced from hill to hill. Here the sinking is very variable in depth, the whole gutter in some places appearing on the side of a cliff where the work merely consists in driving, while in other places shafts up to 60 or 70 feet have to be sunk to work the same lead. Up to the present only one of these leads has been discovered, but there cannot be the least doubt that more will be found when the small hills between the conglomerate range and the creek are thoroughly prospected. All three of these deposits are very rich, but no one can estimate the quantity of gold with any degree of accuracy, as so much leaves the Colony without ever being reported.*

Marble Bar, the official centre of the Pilbarra Goldfield, derived its name from a mottled bed of quartzite, which crosses the Coongan River in close proximity to the town. Quartz reefs are very prominent in the district, and vary very much in size and character, some of the quartz being very highly mineralised. Many of the reefs have proved exceedingly rich. A considerable quantity of gold has been derived from alluvial deposits in the early days of the field.

The country rock of the Shaw Diggings consists chiefly of granite, associated with schistose rocks, quartzite, and diorite dykes. The strata inclined at high angles to the Westward. The reefs are well-defined and exhibit well-marked lateral continuity.

The mining centre of Tambourah lies near the junction of an enormous mass of granite and hornblende, schists and diorite. The reefs as seen outcropping on the surface are small, but widen out in depth. The quartz is associated with ores of iron, copper, and manganese.

The following table shows the yield of the Pilbarra Goldfield up to the close of 1899, as deduced from official data:—

Yield of Pilbarra Goldfield.

Year.	Ore crushed.			Yield of Gold therefrom.			Gold exported.			Remarks.
	tons	cwts.	qrs.	ozs.	dwts.	grs.	ozs.	dwts.	grs.	
1889							a 11,170	0	0	a. Includes export from West Pilbarra.
1890							a 16,055	6	6	b. Includes 2,082ozs. from unknown tons.
1891							a 11,875	0	0	
1892	c			b 22,582	11	0	a 12,892	16	0	c. Details not available.
1893							a 11,698	10	0	
1894							a 16,254	10	0	d. Includes 427ozs. from West Pilbarra.
1895							a 19,522	8	0	
1896	4,270	0	0	d 5,888	0	0	a 11,810	2	4	e. Includes 2,000ozs. of alluvial and 102ozs. dollied and specimens.
1897	5,138	14	0	6,825	5	7	a 11,955	17	9	
1898	6,719	15	0	e 14,413	15	23	11,962	11	5	
1899	7,587	11	0	f 19,316	19	13	19,996	8	1	f. Includes 2,608ozs. 5 dwts. 18grs. of alluvial, and 833ozs. 14dwts. 9 grs. dollied and specimens.
Total	**23,716**	**0**	**0**	**69,026**	**11**	**19**	**154,893**	**9**	**1**	

* Annual General Report for the year 1890. H. P. Woodward, Perth: By Authority: 1891: p. 25.

West Pilbarra Goldfield.

The West Pilbarra Goldfield, about 10,500 square miles in extent, originally included in the Pilbarra Goldfield, was created a separate field on the 19th of September, 1895.

The authorities define the boundaries as follows :—

The portion of Crown lands bounded by a line starting from the Sea coast, at the mouth of the Fortescue River, and extending along the right bank of the said river upwards to Survey Station V23; thence in a Northerly direction through Survey Station V32, to the right bank of the Cocreaca branch of the Yule River, and the right bank of the Cocreaca Creek and the Yule River, downwards to the Sea coast, and along the Sea coast Westwards to the starting point.

Very little is known with reference to the geological features of the West Pilbarra field.

Mining operations, however, are confined at the present time to but a few centres.

The Mallina Diggings, the scene of the first discovery of gold in the North-West in 1888, lie about 70 miles East of Roebourne. The gold in the reefs is associated with sulphide of antimony.

Toweranna Diggings lie about 14 miles South of Malina. The country rocks consist of schists, slates, porphyry, and diorite. The quartz of the reefs is of a blue colour, and contain ore of lead and iron disseminated through it.

The mining centre of Pilbarra, from which the field originally derived its name, lies within the drainage area of one of the heads of the Yule River. A fairly large quantity of alluvial gold has been obtained from a narrow strip of country at the junction of granite and metamorphic rocks.

Yield of the West Pilbarra Goldfield.

Year.	Ore crushed.	Yield of Gold therefrom.	Gold exported.	Remarks.
	tons. cwt. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	
1889	160 0 0 (1889–1896)	337 18 0 (1889–1896)	*a*	
1890			*a*	
1891			*a*	
1892			*a*	
1893			*a*	*a* Previously shown in the Pilbarra (*Vide ante*).
1894			*a*	
1895			*a*	
1896			*a*	
1897	608 17 0	860 1 10	*a*	
1898	202 6 0	326 14 0	2,028 5 10	
1899	879 17 0	*b*1,934 16 1	1,955 10 2	*b* Including 735ozs. 1dwt. 11grs. alluvial.
Total	**1,851 0 0**	**3,459 9 11**	**3,983 15 12**	

Ashburton Goldfield.

The Ashburton Goldfield was proclaimed on the 25th December, 1890, and on the 25th of June, 1897, the boundaries were somewhat amended, and the field reduced in area to about 6,992 square miles.

As at present constituted the boundaries as defined by the authorities are as follows:—

Bounded by lines starting from the summit of Mount Elizabeth, which is situated about six and one-half miles from the junction of Duck Creek with the Ashburton River, and extending East by North to the summit of Mount Edith; thence South-East by East to the summit of Mount DeCourcey; thence about East by South to the summit of Mount Wall; thence about South-East by East to Trig. Station 10/\; thence about South-East by South to the summit of Mount Bresnahan; thence about South-West by South 37 miles towards Trig. Station K20; thence by a line running about North-West by West to the summit of Mount Palgrave; thence North by West to the summit of Mount Florry; thence North by East to the summit ot Mount Elizabeth, the starting point.

The Ashburton Goldfield never having been geologically examined in any detail, our information in connection with its various formations and the mode of occurrence of the ore deposits is extremely meagre.

Alluvial gold was first reported from the district early in 1890, as occurring in a creek flowing over clay slates upon which rest horizontally-bedded limestones.

In describing the mineral resources of the Colony, in the annual report of the Government Geologist for 1890 it is stated that:—

These clay slates dip at a high angle to the North-East. They are intersected in places by small quartz reefs or leaders, in many cases ferruginous, but up to the present none of them have proved to be rich in gold. The capping limestone (dolomite), the underlying shaley sandstone and ironstone beds are probably a Northern and Eastern extension of the Carboniferous and Devonian formations, so largely developed on the Lyons and Gascoyne Rivers, though as yet no fossils have been found by which their age can be definitely fixed. The beds dip at an angle of 20° South, resting unconformably upon the upturned edges of the clay slates (Silurian ?), and from their line of junction many strong springs break out. To the South, these limestones form a flat-topped range or tableland, and completely covering the clay slates, which are not exposed again, even in the gullies and the stream beds, although these are often of great depth.

There cannot be the least doubt that the gold in the gullies has been derived directly from the mineral veins in the clay slates, for it has never been found in those gullies where the slates are absent, as the overlying limestones contain no mineral veins. The mineral veins must be of great antiquity, as they were formed prior to the deposition of the superincumbent Carboniferous and Devonian rocks, for in no case do they extend beyond the line of junction.

It is rather remarkable that there are no conglomerate beds in this district at the junction of these two formations, the limestone for the most part resting directly upon the upturned edges of the clay slates. Should any such conglomerate or detrital deposits be discovered, they should be prospected, as it is highly probable they would prove rich in gold.

The gold on this field is very pure, and free from quartz and ironstone. All the larger pieces were of a flat bar shape, owing to their having been formed between the slate ledges by the slow accumulation of fine gold, which by the gradual accretion, due to the deposition of the minute quantities of gold held in solution by the water, has formed into one piece, taking the shape of the cavity or ledge. The largest nugget yet found weighed about 6lbs., and it is estimated that from 9,000 to 10,000ozs. have been taken from these diggings. The run of gold in the main gully extended for over one mile in length, but most of the gullies North and South, for a distance of about five miles along this line, have proved rich.

Whence this gold was derived it is impossible to say without carefully mapping and prospecting the area, but it is highly probable that it results from slow accumulation from poor quartz and ironstone reefs, though in some cases it may have been washed from older "leads" and conglomerate beds which, if they existed, must have followed the present courses of the creeks, for no trace of such beds are now to be seen. *

Yield of the Ashburton Goldfield.

Year.	Ore crushed.	Yield of Gold therefrom.	Gold exported.	Remarks.
	tons cwt. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	
1891	a	a	838 14 10	a No detailed records given.
1892	a	a	0 14 0	Do.
1893	a	a	467 14 22	Do.
1894	a	a	285 5 10	Do.
1895	a	a	540 15 4	Do.
1896	a	a	669 3 9	Do.
1897	a	b302 19 0	1,038 3 13	b Dollied and specimens.
1898	a	c500 0 0	449 17 12	c Alluvial, dollied and specimens.
1899	a	d1,659 2 0	239 10 3	d Alluvial, dollied and specimens
Total	...	**2,426 13 12**	**4,529 18 11**	

Gascoyne Goldfield.

This goldfield, which embraces an area of about 5,061 square miles, was officially proclaimed on the 25th of June, 1897. The boundaries are thus defined by the authorities :—

Starting from the summit of Mount Palgrave, and extending about South-East by South to a point situate 37 miles from the summit of Mount Bresnahan in direction of Trig. Station K20; then about South-West by South to the said Trig. Station K20; thence about South-West to the summit of Mount Gascoyne; thence about North-West by North to the summit of Mount Agamemnon; thence Northward to the summit of Mount Palgrave, the starting point.

The field, though geographically distinct, has been placed under the charge of the same Warden as the Ashburton.

* Annual General Report for the year 1890, H. P. Woodward, Perth: By Authority, 1891; p. 20.

Very little is known of the geology of the field, but it appears that the staple formation is of granite and crystalline rocks, which are covered in places by almost horizontal tablelands of sandstone shale and limestones, for which a Carboniferous age has been claimed.

Prospecting operations are chiefly confined to the neighbourhood of Bangemall, the official centre of the field, but no details as to the nature and mode of occurrence of the ore deposits are available.

The yield of this goldfield, as can be seen by the official figures appended, is small.

Yield of the Gascoyne Goldfield.

Year.	Ore crushed.	Yield of Gold therefrom.	Gold exported.	Remarks.
	tons cwt. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	
1897	1 7 0	*a*13 11 0	*d*	*a* Includes 6ozs. 15 dwts. dollied and specimens
1898	*d*	*b*13 10 0	*d*	*b* Dollied and specimens
1899	235 7 0	*c*333 15 10	333 1 8	*c* Includes 119ozs. 8dwts. 16grs. alluvial
Total	**236 14 0**	**360 16 10**	**333 1 8**	*d* Details not available.

Peak Hill Goldfield.

The Peak Hill Goldfield, which comprises an area of about 12,194 square miles, was established on the 19th of March, 1897. The authorities define its boundaries as follows:—

The portion of Crown lands bounded by lines starting from an angle in the Northern boundary of the Murchison Goldfield, at the summit of Mount Hale, and extending along the said boundary in an East-South-Easterly direction to another angle at the summit of Mount Russel; thence due North to the North-Easterly corner of the East Murchison Goldfield, latitude being on the 26th parallel of South latitude; thence in a Northerly direction to Trig. Station L15 on Wonyuegunna Hill; thence in a North-Westerly direction to the summit of Mount Bresnahan, between the Angelo River and the Upper Ashburton; thence in a South-Westerly direction to Trig. Station K20 on a peak near the source of the Lyons River; thence still South-Westerly to the summit of Mount Gascoyne; thence South-South-Easterly to the starting point on the summit on Mount Hale.

The goldfield includes within its boundaries the high ground lying at the heads of the Gascoyne and the Murchison Rivers.

At the present time mining operations are chiefly confined to Peak Hill, the official centre, and the Horseshoe Diggings, some miles to the North.

The goldfield was discovered some time about the year 1892.

By far the larger portion of the goldfield upon which mining operations on any scale are carried out consists of undulating country, situated on the lofty plateau drained by the heads of the Murchison and the Gascoyne Rivers.

The country rock of the field consists of banded and in places granular quartzites (with secondary silica), micaceous schists, and banded iron-bearing schists or quartzites; there are no signs of any intrusive rocks anywhere in the vicinity of Peak Hill itself. The quartzites and iron-bearing schists generally appear as fairly conspicuous ridges, whilst the micaceous beds, owing to their feebler resistance to denuding agencies, form the flat or gently undulated portions of the ground. The quartzites and mica schists are vertical, or are inclined at very high angles, but seem to have no prevailing strike. From an examination of the outcrops of the various quartz schists, it is quite evident that a good deal of earth movement must have occurred since the beds were first laid down, and before they were brought into their present position. This is further emphasised by an inspection of the sections exposed below ground in the mine workings.

A remarkable feature in the surface geology of the goldfield are the masses, veins, or dykes of pure silica; in a few places there, veins have the appearance of massive quartzite, but their mode of occurrence, at angles transverse to the strike of the adjacent strata, confutes this view; further confirmation is to be found in the fact that in one of the mines a vein of this character is seen cutting across an auriferous quartz reef, and that one of the most noteworthy masses bifurcates after the usual manner of igneous dykes.

The majority of the quartz dykes trend North-East and South-West, and preserve rude parallelism, which, however, is only observable when their position is laid down on a map. In isolated cases there can also be observed another set of quartz dykes roughly at right angles to those last described. The quartz veins are generally inclined at high angles, but not far from the vertical. So far as experience has already gone, it would not appear that these quartz dykes, although auriferous, have proved to be so remuneratively. One of the most significant features in the geological structure of the field is the fact that the richest portion thereof is that which is least intersected by the large quartz dykes.

Somewhat similar in their mode of occurrence are those large masses and dykes of hydrated oxide of iron which are such a conspicuous feature in some portions of the field.

Resting upon the underlying rocks of the field is a variable thickness of recent superficial deposits. These consist of loose gravel or loam, from which gold is obtained by the usual method of dry-blowing. There is, unfortunately, no record as to what amount of gold has been obtained from this loose material, unless it is represented by the 3,349ozs. recorded in 1895.

This gravel reposes directly upon an irregular surface of an ironstained cement. This cement rests upon an old eroded water-course, and fills up all the inequalities in the latter, which, however, are of no great depth. On the surface of the cement are several large pot-holes, which owe their present form to the gyratory movement of the gravel swept down by the water which flowed down the old channel. In some cases erosion has succeeded in cutting down the cement to bed rock, and exposing the underlying schists. Lithologically the cement is an ordinary conglomerate, formed by the mechanical action of water, and deposited in an old creek bed; its pebbles were derived from the disintegration and subsequent deposition of the pre-existing rocks. The pebbles are embedded in a matrix of sand, formed of the comminuted remains of the underlying rocks. The component parts of the cement are in every way identical with those of the rocks at present out-cropping, whilst the number of quartz pebbles are similar in character to the quartz forming those reefs by which the country rock is traversed.

The gold in the cement is not exclusively in grains, scales, or nuggets, but is also found attached to its original quartz matrix. The amount of gold won from the cement has been considerable; the official returns demonstrate that. Up to 1897 1,964 tons of cement crushed have yielded 2,105ozs. 7dwts. of gold, or at the rate of 1oz. 10grs. per ton. Whether the 3,349ozs. of gold returned from an unknown tonnage of quartz has been obtained from the cement or from the superincumbent loose gravel, the official data afford no clue.

In the mode of occurrence the ore bodies, apart from the cement, may be described as a mass of country rock traversed by a network of interlacing veins of auriferous quartz. The mass of country rock is weathered in the direction of kaolin, and possesses, unless in exceptional cases, no sharply defined limits. The gold is not confined to the reefs or veins, but is disseminated through the decomposed country rock.

So far as mining operations have at present been carried, it seems that the richest portions of the fields are those which have undergone the greatest amount of earth movement.

The Horseshoe Diggings are situated on the North-East flank of that sigmoidal-shaped range, of which Mount Beasley forms the highest summit. The Horseshoe Range has a general North and South trend, and is virtually continuous with that low line of hills which extend as far as the township of Peak Hill.

The Range is composed of hematite-bearing quartzites, which dip at a high angle to the West. The outcrop of the iron-bearing series forms the most conspicuous feature of the range, and is visible for great distances. The individual beds are in places minutely puckered and contorted. At the actual summit of Mount Beasley the dip of the iron-bearing quartzite is to the South, at an

angle of 40 degrees. The flats to the North are underlaid by micaceous schists, which readily lend themselves to the action of the weather, and in consequence never form any conspicuous feature in the landscape. The Northern face of the range is drained by several gullies, the most important of which is Nuggety, Prospectors', and Webb's. From the former £16,000 worth of gold is reported to have been obtained by dry-blowing. The area already worked over by the dry-blower is comparatively small, and considering the results which have been obtained, and the abnormally high returns obtained from some of the ore bodies already worked, there are good grounds for a system of judicious prospecting over the creeks and flats yet untried. There are no data by which the yield of gold obtained by the dry-blowers can be deduced.

The following table shows the yield of the Peak Hill Goldfield:—

Yield of the Peak Hill Goldfield.

Year.	Ore crushed.			Yield of Gold therefrom.			Gold exported.			Remarks.
	tons	cwts.	qrs.	ozs.	dwts	grs.	ozs.	dwts.	grs.	
1894	33	10	0	898	14	20	*a*			*a*. Included in the Murchison Export Return.
1895	197	16	0	*b* 5,749	14	7	*a*			*b*. Includes 3,349ozs. 8dwts. 23grs. from unknown tonnage.
1896	1,712	2	0	4,422	0	0	*a*			*c*. Includes 399ozs. dollied and specimens.
1897	2,992	6	0	*c* 10,174	19	3	5,110	0	0	*d*. Includes 368ozs. 16 dwts. dollied and specimens.
1898	4,018	1	0	*d* 14,969	6	12	13,736	17	1	*e* Includes 478ozs. 18 dwts. dollied and specimens.
1899	10,922	0	0	*e* 31,953	13	0	15,721	6	17	
Total	**19,875**	**15**	**3**	**68,968**	**11**	**18**	**34,568**	**3**	**18**	

Murchison Goldfield.

The Murchison Goldfield, as originally constituted, was first proclaimed on the 24th of September, 1891; its boundaries were modified on the 15th of February, 1895, so as to embrace an area of about 21,000 square miles. As defined by the authorities, the goldfield is:—

Bounded by lines starting from the summit of Mount Murchison, and extending North-Eastward to the summit of Mount Hale; thence East-South-Eastward to the summit of Mount Russel; thence South-Westward to the North-West corner of the Yilgarn Goldfield; thence West-North-Westward to the summit of Wyemandoo Hill, and onwards to Trig. Station K6, on Goonamondey Peak; thence North-Westward to the summit of Mount Farmer; and onwards to the summit of Mount Luke, and onwards to the summit of Mount Murchison.

The geology of the Murchison Goldfield has been investigated by nearly the whole of the geologists employed by the Government, as well as by private observers, hence our knowledge of the broad structural features is perhaps more complete than that of any other of the goldfields of the Colony.

There are four formations, according to Mr. Woodward, exposed on the Murchison Goldfield, viz.:—

Recent.—The alluvium of the water-courses, flats, and salt marshes, travertin, and other surface deposits.

Mesozoic.—Desert sandstone, horizontally-bedded sandstones, clay, pipeclay, gypsum, and ferruginous beds.

Metamorphic.—Slate, schists, quartzite, sandstones mostly ferruginous limestone or granite.

Plutonic.—Granite, diorite, and other dykes.

The recent formations are always of very limited thickness, rarely, as far as yet tested, exceeding 15 to 20 feet. . . . . The Mesozoic (?) formation, if represented by the remains of the old tableland, can be seen well in many cliff sections, but up to the present time no organic remains have been found in them: but to judge from the associated gypsum and iron beds it is highly probable that some will yet be met with. . . . . . It is very strange that no gold has been found in this formation, although it rests directly on the gold-bearing rocks and capping hills at the base of which rich reefs have been found. That gold will be found in rich deposits at the junction of these two formations one would naturally expect, as the auriferous reefs must have been infilled prior to the deposition of the more modern formation, otherwise we should have had the fissure continued on up from one into the other, but this is never the case. . . . . The Metamorphic rocks outcrop, rising as low ridges wherever the overlying desert sandstone tableland has been removed; they are mostly hard, large quartz reefs, often forming the main axes of the ridges, but more generally beds of highly-altered ferruginous quartzite, nearly approaching a mineral vein in character, at the intersection of which the quartz reefs are always richest.

Along the principal belt of auriferous country, the rocks for the most part strike a little to the Westward of North, and underlie to the Westward, consisting largely of talcose and granitic rocks, although hornblende and micaceous slates are also met with. Where there are patches of limestone the surface is covered by travertin deposits and the veins are mostly of a ferruginous calcite, in some of which gold has also been found.

The rocks at the North end of the field take a sudden turn to the North-East and East. Dykes are met with in many places: these are generally either granite or diorite, the latter being of great variety, whilst the former generally contain crystals of foliated talc in cavities.

The mineral veins consist mostly of quartz, but ferruginous lodes and veins of calcite and dolomite also exist. The quartz is of great variety, from pure white, with talc in the granite country, to white, blue, and highly mineralised in other places, whilst the dolomites and calcites are mostly ferruginous.

Where the reefs have been opened up to the water-level many of them contain galena as well as iron pyrites, and veins seem for the most part, as far as one can judge at present, to be true fissure veins, most of them probably continuing in depth; but they will vary greatly in size, direction, and thickness, and many will have to be traced by a mere line or face for a considerable distance. The veins rarely follow the strike or dip of the other rock, but cut across them in all directions, and when they are lost at the ends they generally seem to turn and strike along the line of bedding of the rocks as a mere thread, for some times a considerable distance, making again into a large body of stone, when they strike off more or less on their old course.

The reefs are found to be very rich in shoots, the gold being mostly met with at the intersection of certain beds, whilst at other places either

large bodies of stone or pinches are accountable to the same cause. The question as to which are the true veins cannot be decided until a more systematic survey of the fields has been made, but in most cases where there is a large main line of reef parallel lines are met with, which it is impossible to trace for any distance; these latter are in all probability not true veins, but only in-filled lateral fissures, which, although often very rich, will not extend for any distance along the surface or in depth.

The main lines of reef seem to follow a more or less North and South course, but there are some very rich ones which strike East and West; these also vary greatly, some being small cross-courses, extremely rich at their intersection with main North and South reefs, and others, such as the Star of the East, which seems of quite a different character to anything else on the field, but which still present all the characteristics of a fine lode of a very broken character, but from the nature of the stone this must be expected until sinking is carried into the solid country. The ferruginous reefs are met with mostly at Quin's. Many of these will prove to carry a very great deal of pyrites in depth, but, as a rule, the reefs on this field are exceptionally free from any objectionable mineral.*

According to Dr. Schmeisser, a considerable area of quartz diorite, of granitic habit, occupies that portion of the Murchison goldfield in the vicinity of Cue, and forms the matrix of the numerous quartz reefs which trend and underlie in all directions. The coarse diorite is decomposed to a depth of about 100 feet in the direction of kaolin, which is of a white but more rarely of a brown colour. The undecomposed quartz diorite appears to approach tonalite in its mineralogical composition.†

For administrative purposes the Murchison Goldfield has been divided into four districts, viz., Nannine, Cue, Day Dawn, and Mount Magnet.

The following figures show the yield of the Murchison Goldfield, since its inception:—

Yield of the Murchison Goldfield.

Year.	Ore crushed.			Yield of Gold therefrom.			Gold exported.			Remarks.
	tons	cwts.	qrs.	ozs.	dwts.	grs.	ozs.	dwts.	grs.	
1891							2,064	8	16	a. Details not available.
1892							24,356	9	12	b. Includes 1,400ozs. 13dwts. 12grs. dollied and specimens.
1893							21,210	8	22	
1894	a110,805	0	0	a140,432	5	15	52,946	6	11	
1895							65,477	5	3	
1896							71,282	13	17	c. Includes 1,119ozs. 2dwts. 10grs. dollied and specimens.
1897	72,003	16	0	b 62,316	3	21	82,891	17	1	
1898	92,255	16	0	c 79,256	7	20	93,667	3	6	d. Includes 214ozs. 2dwts. 15grs. alluvial, and 2,844ozs. 9dwts. 22grs. dollied and specimens.
1899	66,986	17	2	d 81,086	5	13	68,842	7	17	
Total	**342,051**	**9**	**2**	**363,091**	**2**	**21**	**482,739**	**0**	**9**	

East Murchison Goldfield.

The East Murchison Goldfield was originally proclaimed in May, 1895, but, for administrative purposes, its boundaries were so

* The Murchison Goldfield. H. P. Woodward, Perth: By Authority, 1893; pp. 9-11.
† Die Goldfelder Australiens. Karl Schmeisser, Berlin, 1897; p. 58.

altered in December 1897 as to embrace an area of about 28,242 square miles, which is thus defined by the authorities:—

Bounded by lines starting from the Southernmost corner of the Murchison Goldfield, situate about four and a-half miles East, and four miles South from Trig. Station K75, on Wyemandoo Hill, and extending East to a spot about 15 miles East, and about 44 miles North from the summit of Mount Ida; thence North about four and a-half miles; thence East about 74¼ miles, passing through a tree marked A.N. 33 at Doyle's Well, to a spot about 2 miles 10 chains West, and about 35½ miles North from a tree marked 1,382 at Brickey's Soak; thence North to the 26th parallel South latitude; thence West to a spot due North of the summit of Mount Russel; thence South to the said summit of Mount Russel; thence South-South-Westward along the Eastward boundary of the Murchison Goldfield to its Southernmost corner, the starting point.

Not very much is known geologically of the East Murchison Goldfield, no detailed examination having been made on the district by any member of the Geological Survey Staff. A report by Mr. F. Reed,* and another by Mr. Torrington Blatchford,† are about the only official data extant.

From the former author's description, it appears that the country consists of foliated granite gneiss, massive and banded diorites, covered with "desert sandstone" and deposits derived from the disintegration of these rocks.

The observations of Mr. Blatchford in the East Murchison Goldfield have shown that granite is the staple formation, which has been invaded by dykes and masses of some basic rock, together with a much later series of intrusions of acidic rocks, which usually form narrow tortuous dykes. Near the junction of the basic rocks and the granite a strong development of hornblende, mica, and iron-bearing quartz schists are of frequent occurrence. These schists are seen to pass gradually into granite in such a way as to suggest that they may be merely highly metamorphosed forms of the latter. These crystalline rocks are covered by sandstones, quasi-vitreous sandstones, and conglomerates, which have been classed, inferentially, as of Mesozoic age. Of a much newer date than these are the deposits of ironstone gravel which cover such an extensive area of country. The origin of these, however, is not quite understood. Their largest development, however, occurs to the West of the Montague Range, which is made up of iron-bearing quartz schists so prevalent in the Mt. Hale district.

There are four principal mining centres on the East Murchison field, viz., Lawlers, Lake Darlôt, Mount Sir Samuel, and Lake Way.

At Lawlers, the reefs are said "‡to occur along the zone of contact between the gneissic granite and diorite schists." The reefs

* The Geological Features and State of Mining in the Lawlers and Mount Sir Samuel Districts. F. Reed. Report of the Department of Mines for the year 1896. Perth: By Authority, 1897; pp. 33-35.

† A Geological Reconnaissance of the Country at the heads of the Murchison and Sandford Rivers, in the Murchison and Peak Hill Goldfields. T. Blatchford. Annual Report of the Geological Survey for the year 1898. Perth: By Authority, 1899; pp. 36-50.

‡ F. Reed. *Loc. Cit.*

have a general East and West trend, and can be followed along the surface for considerable distances.

The Mount Sir Samuel mining centre is situated at the Southern end of the Violet Range, immediately to the North of Lake Miranda. Stretching from Lake Miranda Northwards, the Violet Range extends as far as the Jones Creek; and consists of a succession of semi-detached hills, the culminating point being Mount Goode, which rises to an altitude of 350 feet above the surrounding country. Geologically, this Range is a diorite boss, occurring in massive granite, of a similar nature to the granite at Lake Way. . . . . . Breaking through the diorite boss, usually in an East and West direction, are numerous granite dykes of apparently a later age. These dykes vary in thickness from a few inches to several feet. They are particularly conspicuous on the sides of Mount Goode, where they can be traced for considerable distances. In close association with these dykes are some very large quartz reefs, which latter, as far as surface indications show, follow the strike of the dykes with great persistency.

At McDonough's Lookout, another apparently disconnected diorite boss is found, with numerous granite dykes intruding, and the associated quartz reefs. The granite dykes in this locality are coarse-grained, and can clearly be seen to consist of quartz, orthoclase felspar, and mica. The mica, however, occurs in two forms, the Muscovite (common white mica), and Lepidolite (lithia mica).

The quartz reefs at McDonough's Lookout are of the white opaque barren variety, and will scarcely recommend themselves to prospectors. Included in the quartz are large irregular mangane-ferruginous nodules in considerable quantity. . . . . In addition to the reefs associated with the granite dykes, other quartz reefs are found in the massive diorite. These latter, for the most part, though sometimes rich in gold, are lenticular, and too expensive to work or prospect for in the hard diorite rock. Besides the quartz reefs, there is one example of a fissure lode being worked, viz., at the Belle Vue Mine. *

The following figures show the crushings and the yield of gold since the date of opening of the goldfield:—

Yield of the East Murchison Goldfield.

Year.	Ore crushed.			Yield of Gold therefrom.			Gold exported.			Remarks.
	tons	cwt.	qrs.	ozs.	dwts.	grs.	ozs.	dwts.	grs.	
1896	1,467	0	0	*a* 2,576	0	0	...			*a* Previous to 1896 the returns were included in the Murchison Field, *vide ante*.
1897	11,763	0	0	*b* 20,995	1	7	9,453	16	6	*b* Includes 443ozs. 3dwts. 8grs. dollied and specimens 621ozs. 3dwts. 16grs. of alluvial.
1898	31,947	19	3	*c* 37,080	6	10	39,563	7	0	*c* Includes 641ozs. 2dwts. 19grs. alluvial, and 1,115ozs. 5dwts. 6grs. dollied and specimens.
1899	42,166	15	0	*d* 45,038	18	5	37,811	11	19	*d* Includes 1,628ozs. 4dwts. 9grs. alluvial, and 1,485 ozs. 7dwts. 17grs. dollied and specimens.
Total	**87,344**	**14**	**3**	**105,690**	**5**	**22**	**86,828**	**15**	**1**	

* T. Blatchford, *Loc. Cit.*

CHAPTER III.

GOLD (*continued*).

MOUNT MARGARET, YALGOO, NORTH COOLGARDIE, YILGARN, COOLGARDIE, BROAD ARROW, EAST COOLGARDIE, NORTH-EAST COOLGARDIE, DUNDAS, DONNYBROOK.

MOUNT MARGARET GOLDFIELD.

This Goldfield, which was previously included in the North Coolgardie Field, was originally proclaimed on the 10th of March, 1897, but its boundaries were amended on the 24th of December, 1897, so as to embrace an area of about 42,154 square miles.

The boundaries, as defined by the authorities, are as follows:—

Bounded by lines starting from a spot about 15 miles East and about 13 miles North from the summit of Mount Ida, and extending North about 25½ miles; thence East about 74¼ miles, passing through a tree marked AN 33 at Doyle's Well, to a spot about 2 miles 10 chains West and about 35½ miles North from a tree marked B 82 at Brickey's Soak; thence North to the 26th parallel of South latitude; thence East to the 125th meridian East longitude, and South along that meridian to a spot due East of said tree marked B 82 at Brickey's Soak; thence West through the said tree to the starting point.

The Mount Margaret Field, which bids fair to rise to some prominence as a gold producer, has never been the subject of an official geological report, hence our knowledge of the mode of occurrence and association of the ore bodies is somewhat meagre.

A very large portion of the surface of the ground is covered with a variable thickness of recent accumulations, derived from the disintegration of the underlying rocks.

The staple formation is granite, granitic gneiss, schists, and quartzites intersected by basic volcanic rocks.

The schists are often vertical, or inclined at high angles, and are traversed with quartz reefs, many fragments of which are strewn over the surface.

Some of the quartzites stand up in bold relief, and can be traced by the eye for some miles across country.

It is associated with one of these bands of quartzite that the ore body in the West Australian Mount Morgan occurs. This quartzite is impregnated with oxide of iron in places, while at others it is very spongy and sintery. The Sons of Gwalia Mine is another, in which the ore body is associated with quartzite or quartz schist.

The mode of occurrence of some of the lodes on the Mount Margaret Goldfield bears a close resemblance to those on the East Coolgardie Field.

The following table shows the yield of the Mount Margaret Field since its inception up to the end of 1898:—

Yield of the Mount Margaret Goldfield.

Year.	Ore crushed.			Yield of Gold therefrom.			Gold exported.			Remarks.
	tons	cwts.	qrs.	ozs.	dwts.	grs.	ozs.	dwts.	grs.	
1895 } 1896 }	231	0	0	*b* 4,992	2	2	*a*			*a*. Previous to 1897 included in North Coolgardie Return. *b*. Includes 300ozs. dollied and specimens.
1897	13,198	14	3	*c* 22,592	1	19	8,685	14	14	*c*. Includes 2,018ozs. 5dwts. dollied and specimens and 588ozs. 16dwts. 20 grains alluvial.
1898	37,506	13	2	*d* 49,717	15	9	43,266	13	20	*d*. Includes 387ozs. 13dwts. 16grs. dollied and specimens, and 675ozs. 4dwts. 22grs. alluvial.
1899	75,713	17	0	*e* 80,123	12	0	64,905	10	12	*e*. Includes 601ozs. 3dwts. 15grs. dollied and specimens, and 345ozs. 4dwts. 18grs. alluvial.
Total	**126,650**	**5**	**1**	**157,425**	**11**	**6**	**116,857**	**18**	**22**	

Yalgoo Goldfield.

The Yalgoo Goldfield was originally proclaimed in February, 1895. Its boundaries, which enclose an area of about 18,921 square miles, are thus defined by the authorities:—

Starting from the summit of Mount Murchison, and extending West-South-Westerly to the summit of Tallering Peak; thence South-Easterly to the summit of Mugga Mugga Hill, and onwards to the summit of Mount Gibson, which lies about 12 miles South-West from Ningham Creek; thence Eastward to Trig. Station K 83, on the West shore of Lake Moore; thence due East to the Western boundary of the North Coolgardie Goldfield, and along it North to its North-West corner; thence North-Westward to the summit of Wyemandoo Hill, and onwards to Trig. Station K 6, on Goonahmondey Peak; thence North-Westward to the summit of Mount Farmer, and onwards to the summit of Mount Luke, and onwards to the summit of Mount Murchison.

Gold was first discovered upon this field in the early part of 1890, at the Nancarrong Hills, which are situated a few miles to the Eastward of Yewin Station, which is about 100 miles North-East of Geraldton and 150 miles South-West of Cue. The gold was found in a large reef of bluish glassy quartz stained with copper, which strikes East and West, and apparently dips at a high angle to the North. The rocks are quartzite and mica slate, with granite dykes and ironstone lodes, which follow the same strike of the reef.*

The same author, writing in 1896, says that the field:—

Is situated upon the high ground immediately behind the range which ses at the head of the Irwin River. It is drained by the Murchison and

* The Yalgoo Goldfield. H. P. Woodward. Mining Handbook to the Colony o Western Australia. Perth: By Authority, 1895; p. 90.

Greenough Rivers, whilst to the Southward all the streams discharge themselves into Lake Monger; of these the Greenough River drains much the largest area; in fact this goldfield may be said to be situated upon the upper courses of that river. The surface is broken and hilly, small stony sides or granite hills rising abruptly from alluvial flats.

The principal centres of the field are Yalgoo, Melville, Gullewa, Pinyalling, Woodley's, Damperrah, and Nancarrong.

Yalgoo, which is the official centre, is situated upon the Cue railway. The reefs occur in a broken belt of schistose country, the strike of which is East and West, whilst the diorite dykes and lodes follow the same lines. Many of these veins were extremely rich, particularly one called the Emerald, where a very showy deposit was discovered, but which, when the company that had purchased it started to work, proved to be, instead of the cap of a lode, a small almost flat reef, with no defined formation and of no extent. Several of the other lodes here are nothing more or less than lenticular bunches of quartz . . . . *

The following table shows the yield of the Yalgoo Goldfield as prepared from official data :—

Yield of the Yalgoo Goldfield.

Year.	Ore crushed.			Yield of Gold therefrom.			Gold exported.			Remarks.
	tons	cwts.	qrs.	ozs.	dwts.	grs.	ozs.	dwts.	grs.	
1895 } 1896 }	a2,488	0	0	a 7,227	0	0	b			a. Details not available. b. Previous to April, 1897, included with Murchison.
1897	3,666	19	1	3,455	15	21	2,034	4	15	
1898	4,424	10	0	3,298	18	21	3,756	7	16	
1899	17,933	10	1	c 12,135	18	20	5,689	10	15	c. Includes 16ozs. 10dwts. dollied and specimens.
Total	**28,512**	**19**	**2**	**26,117**	**13**	**14**	**11,480**	**2**	**22**	

North Coolgardie Goldfield.

This goldfield embraces an area of 30,609 square miles, and, according to the authorities, is circumscribed :—

By lines starting from the Southernmost corner of the Murchison Goldfield, being the South-West corner of the East Murchison Goldfield, and situate about 12 miles East and five miles South from Trig. Station K 75 on Wyemando Hill, and extending South to the South-East corner of the Yalgoo Goldfield, which is a point due East from Mount Gibson, near Lake Moore, and due North of a spot 10 miles West of a cairn on Yorkrakine Granite Rock; thence East-South-East to a point about 50 miles due West from a cairn marked NB 1, near Wangine Soak; thence East to Survey Station NB 1.; thence about 87° 20 miles 22 chains to Survey Station R 3; thence East to the 125th meridian East longitude; thence North along that meridian to a point East of a tree marked B 82 at Brickey's Soak; thence West through the said tree to a spot about 76¼ miles West from it, and 13 miles North and 15 miles East from the summit of Mount Ida; thence North about 31 miles to the South boundary of the East Murchison Goldfield, and West to the starting point.

* The Yalgoo Goldfield. H. P. Woodward. Annual Report of the Department of Mines for the year 1895. Perth: By Authority, 1896; pp. 21-22.

This field, which originally formed part of Coolgardie, has, for purposes of administration, been subdivided into the Menzies, Ularring, Niagara, and Yerilla districts.

In its topographical features, Menzies is very hilly, the ground ranging from 1,330 to 1,660 feet above sea-level. The most prominent feature in the district is a more or less continuous ridge on the East, trending approximately North-West and South-East, and from which spurs radiate towards the West. The area over which most of the productive mines are situated lies at the foot of the main ridge, though at some considerable distance to the Westward.

In its geological structure, the field presents features which connect it geologically with those of Kalgoorlie and Coolgardie. The country rocks of Menzies consist of granite, gneiss, hornblende, mica, sericite, and serpentinous schists, associated with amphibolites, ferruginous quartzite, and diorite dykes. Felsite dykes have been noticed in some parts of the district. Ferruginous conglomerate, passing in places into pure limonite, occupies the caps of certain of the hills. All the rocks have suffered a considerable amount of decomposition, which extends to a depth of about 100 feet from the surface.

The lodes of Menzies, which are of a more or less schistose habit, have an approximate parallelism; they trend generally North-West, and have a fairly high underlie to the West. The gold occurs associated with iron, copper, and arsenical pyrites, galena (which is very abundant), and zincblende. Free gold occurs in the rocks within the zone of oxidation.

No geological examination of the other districts having been made, no details in connection with the ore deposits are available.

The table shows the yield of the North Coolgardie Field :—

Yield of the North Coolgardie Goldfield.

Year.	Ore crushed.			Yield of Gold therefrom.			Gold exported.			Remarks.
	tons	cwts.	qrs.	ozs.	dwts.	grs.	ozs.	dwts.	grs.	
1896	*a* 13,414	10	0	*b* 26,577	15	10	*c* 17,160	10	4	*a.* Complete details not available. *b.* Complete details not available, but includes 275ozs. from unknown tons.
1897	33,691	15	0	*d* 61,747	18	3	74,556	2	12	*c.* Included with Coolgardie prior to 1st May, 1896.
1898	42,032	15	3	*e* 72,878	17	12	70,625	6	4	*d.* Includes 391ozs. 2 dwts. 12grs. of dollied and specimens, and 120ozs. of alluvial.
1899	93,376	5	0	*f* 117,138	5	4	60,909	7	16	*e.* Includes 924ozs. 6 dwts. 8grs. of dollied and specimens. *f.* Includes 1,118ozs. 6 dwts. 19grs. of dollied and specimens, and 796ozs. 15dwts. 13grs. of alluvial.
Total	**182,515**	**5**	**3**	**278,342**	**16**	**5**	**223,251**	**6**	**12**	

Yilgarn Goldfield.

The Yilgarn field, as officially declared, embraces an area of 15,593 square miles:—

Bounded by lines starting from a point 90 miles South of a cairn, H 26, on Koorarawalye Granite Rock, and extending West to a point due South of a point 10 miles West of a cairn on Yorkrakine Granite Rock; thence North to the South-East corner of the Yalgoo Goldfield; thence East-South-East to a point about 50 miles due West from a cairn marked NB (conjoined) 1, near Wangine Soak; thence South through the before-mentioned cairn H 26 to the starting point.

The occurrence of gold in what is now the Yilgarn Goldfield would seem to have been made known by Mr. Glass, of Mugakine, in the year 1887.

According to H. P. Woodward:—

The Yilgarn Hills are a low range of hills about 250 miles East of Perth, and are on the Western side of a series of salt lakes, of which Lake Deborah is the Southernmost one. They are from two to three miles in width East and West, whilst the general direction of the range is from North and South. The Western face is somewhat steeper than the Eastern, which gradually descends towards the lakes, from which it is separated by a plain, of from four to six miles in width, of red clay strewn with ironstone and quartz. The rocks are mica schist, mica slate, and shaly quartzites, with many diorite dykes and quartz veins. Their general strike is North and South, with an Easterly dip. They have been tilted up from the West by a large mass of intrusive granite, which forms a rough Western face to the hills in the Northern part; but to the South it is only seen appearing above the surface of the plain in large rounded masses. The quartz reefs follow the strike of the rocks, but vary greatly in character, the white quartz being, as a rule, not in such large masses or so well defined as the more ferruginous ones.

The same author notes that the quartz reefs of the granite:—

Are either white quartz containing some pyrites, but not well defined, large yellow jaspery reefs, or large blue and ferruginous banded quartz veins, with some hematite, but not of a very promising appearance; whilst in the slate country to the East they are more lenticular masses of white quartz with ironstone, some of which can be traced for a good distance, but mostly only a few feet; but these veins have a far more promising appearance than those in the granite. The most Northern portion of the field is called Golden Valley, the mines being situated in a small valley which runs North and South. The rocks here are very hard hornblende schists, with small quartz reefs and large ferruginous and jaspery quartz dykes, the former of which carry gold. The quartz is of a granular character, often almost approaching a sandstone, and contains, in places, large quantities of iron pyrites, whilst some of the small rich offshoots contain a great deal of copper pyrites. The lodes which have proved auriferous form three lines, the Eastern and Western being both small and poor in gold, and, to judge from the formation, are probably legs or branches of the same lode, as the country here forms a sharp anticlinal fold, the junction cap having been denuded. These reefs contain little mineral, and the gold is in a very fine state through the stone, but they are rather small in size to pay. The other line was discovered between these two at the centre of the valley, and did not outcrop at the surface at all. It was immensely rich at the cap, which consisted mostly of gossan, often copper-stained. This reef splits in two, one branch dipping West and one East. The Eastern one seems the best formed, and has been opened up to a considerable depth, where it consists of white quartz with pyrites, whilst in the country between the two branches there are numerous leaders containing a great deal of copper pyrites rich in gold.

The Eastern branch has been followed for a considerable depth, and proved very rich, showing gold freely all the way down; but it takes a most irregular course, turning and twisting about, and apparently cutting out in places only to make again into a larger mass of stone.

Hope's Hill is about 30 miles South of Golden Valley; the lode here forming the main ridge of the country running North and South, and gradually rising from the lake level at the South end to about 200 feet above it at the North end. The quartz on the main hill is of a white hungry-looking character, but carrying fine gold in the stone and clay partings, particularly on the East side of this reef, in a white magnesian clay full of quartz grit. On this side of the reef there is a mass of whitey-brown and greenish-blue banded clay, probably resulting from the decomposition of a serpentine rock, full of small quartz leaders, of a curious gritty nature. These leaders are, as a rule, rich in gold, and in some parts gold is also met with along the joints of the clay, but for the most part it is not visible, though, on crushing, good results are obtained. The bulk of the reef is a white stone of barren appearance, though here and there are bands containing iron, which yield, on crushing, very good prospects of gold. The reef, which is about fifty feet wide at the surface, seems to be in reality a series of reefs separated by partings or casings of a white greasy clay.

The richest stone is found in the mass of leaders to the East of the reef; but the main portion is useful for crushing with the mullocky portion. To the Southward this reef decreases in size, but there, still, the same size patches of stone are met with, but the clay becomes more solid, and presents more the appearance of a decomposed dyke of a greenish tinge; the gold often being met with on the faces like thin paint. There is an enormous lode formation, with shoots of stone first on one side of the lode then on the other; these, had they been picked, would have yielded good returns, but as it was considered more economical to crush the whole of the lode stuff taken out, the crushings have been low, but this system will cease when the work of development is complete. No water has yet been struck in the mine, as the water level is some 100 feet below the level now being driven into the hill. This reef, owing to the fact that it rises up out of the plain, could be easily and cheaply worked, and considering the great mass of stone which carries gold, it would pay well to work on a large scale.

Near the lake there are some pyrites lodes which contain a good deal of gold.

Southern Cross is situated about thirty-five miles to the South of Golden Valley. There is here a series of reefs running more or less North and South, which appear to have been formed at different periods; but without carefully mapping this district, when it has been sufficiently opened out, it is impossible to express a certain opinion on this point; for the present it is enough to say that there are three lines of true lodes, one white, one ferruginous, and one mullocky with quartz leaders, and one series of cross-courses.

These true lodes apparently owe their origin to the great upheaval which has taken place on the Eastern and Western sides of this area, to which they run parallel, while the cross courses are due to a later intrusion of granite, masses of which stand out as bold, bare, isolated hills.

The country is of comparatively slight elevation, consisting of low, thickly timbered hills, flats, and claypans, or lakes, the reefs for the most part appearing on the low ridges, but in some cases they were also visible on the edges of the lakes. The rocks are chiefly hornblende schists, but micaceous, chloritic, and talcose schists also occur, while both to the East and West metamorphic and intrusive granites appear, and occasionally trap dykes are found.

The Eastern is the main line on which the principal mines are situated. It is of a large size, and the quartz is thoroughly mineralised, but does not contain any minerals which will interfere with the abstraction of the gold.

The general description of the lode mass is a large inter-bedded lode, well formed in the deeper ground, between two good walls, striking a little to the West of North, and dipping at an angle of about 80 degrees to the Westward.

This mass varies in width from 5ft. to 30ft., but it rarely consists entirely of stone, especially in the larger portions, where a series of lenticular masses of quartz are met with, the rest of the lode being composed of broken country intermixed with smaller veins and leaders of quartz.

These quartz masses often extend along the line of reef for 100ft., and are generally the richest portion of the lode, and are sometimes met with on one wall and sometimes on the other. The stone is of a highly mineralised character, containing a small quantity of galena, pyrites, and chlorite, the latter often giving the stone a greenish appearance. These reefs are often a good deal iron-stained at the surface, with red clay partings and walls, the foot wall being well formed, whilst there is, at the upper part of the lode, no hanging wall; but the reef splits up into numerous veins and leaders, which strike away into the country.

The rich portions run in well-defined shoots, but it is also rich enough in gold throughout the reef to pay if worked on a large scale.

At the Northern end of this line the reef seems to split into two branches. In the Eastern one there is a great deal of serpentine, which is often very rich in gold.

The stone from this line, when crushed, has always averaged 1oz. to the ton of stone, so they have proved so far payable. The ferruginous line contains a large quantity of jasper, and some very rich specimens were found at the surface, but nothing much has yet been done to test this line in depth.

The Western line is evidently a decomposed dyke, and in one place contained some very rich stone in patches for a considerable depth, but little has been done on it yet.

There is another rich reef, about 15 miles South of Jacoletti's, on a small range (Parker's Range) of schistose rocks to the Western side of a large salt swamp or claypan. There are several lines of reef; but most of the claims have been taken up on one which runs in a North and South direction, dipping to the West.

These reefs contain more pyrites than those at the Southern Cross; but this is only seen below the water level, for near the surface it is decomposed, thus liberating the gold, which shows freely in the stone.

About five miles South there are another series of reefs, which are as a rule small but well defined, carrying rich shoots or patches of gold. At Parker's Range the reef again dips West in pretty firm country, the stone containing a great deal of iron pyrites (mundic), which will carry the gold in depth.

The whole Yilgarn field seems to follow one anticlinal fold in the country, the centre of which is exposed at Golden Valley, where the reefs dip both East and West, where the country is hard and the stone carries much copper.

Hope's Hill and Southern Cross are on the Western side of this fold, whilst Blackborne's is on the other side of a synclinal still further West, where the reefs dip to the East. All along this line of country the stone is highly mineralised, containing carbonate of iron and chlorite.*

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* H. P. Woodward. Mining Handbook, *Loc. Cit.*

The following table gives the yield of the Yilgarn Goldfield :—

Yield of the Yilgarn Goldfield.

Year.	Ore crushed. tons	cwt.	qrs.	Yield of Gold therefrom. ozs.	dwts.	grs.	Gold exported. ozs.	dwts.	grs.	Remarks.
1889							1,858	10	0	
1890							2,277	0	0	
1891							12,833	5	23	*a*. Details not available.
1892							21,209	9	18	
1893	*a* 174,925	0	0	*b* 94,194	11	21	75,744	10	23	*b*. Details not available, but includes 738ozs. 3dwts. 12grs. of dollied and specimens.
1894							31,498	7	17	
1895							19,747	15	2	
1896							16,565	5	0	
1897	35,988	0	0	17,072	16	12	17,994	9	13	
1898	27,807	7	0	11,769	8	1	11,696	3	13	
1899	33,403	3	2	16,371	15	13	7,734	6	21	
Total	**272,123**	**10**	**2**	**139,403**	**11**	**23**	**219,159**	**4**	**10**	

Coolgardie Goldfield.

The Coolgardie Goldfield embraces an area of 11,974 square miles, and is defined by the authorities as being :—

Bounded by lines starting from the North-East corner of the Yilgarn Goldfield (which is a point about 50 miles West from a cairn marked NB1, near Wangine Soak), and extending South about 118 miles through a cairn H26 on Koorarawalye Granite Rock; thence East about 133 miles through the summit of a granite rock near the 50-Mile Soak, on the Dundas and Lake Lefroy Road; thence North about 48 miles to a point 35 miles East of the South-East corner of Hampton Plains Location 48; thence West 35 miles to the South-East corner of the above-mentioned Location; thence along the boundaries (surveyed) of Location 48, Westerly 443 chains 91 links, Northerly 564 chains 87 links to the South-East corner of Location 51; thence along the boundaries (surveyed) of that Location Westerly 160 chains, Southerly 60 chains, Westerly 119 chains 87 links to the South-West corner of Location 51; thence Northerly 400 chains along the Westerly boundary of Location 51 and the Eastern boundary of Location 53 to the North-East corner of Location 53; thence along a surveyed line 324° 16′ 36 miles 1,481 links; thence North 30 miles 47 chains 46 links along a surveyed line to a tree R3, near Cane Grass Swamp, on the 90-Mile Road; thence Westerly about 50 miles to the starting point.

Previous to 20th March, 1896, the Coolgardie Goldfield embraced the present Coolgardie, East Coolgardie, North-East Coolgardie, and Broad Arrow Goldfields, all of which, together with the present Yilgarn field, were originally known as the Yilgarn Goldfield.

Coolgardie Goldfield, as at present constituted, was officially declared on the 20th of March, 1896, and, for purposes of administration, was eventually divided into the Coolgardie and Kunanalling Districts.

Coolgardie.—The area of the mining centre in the vicinity of Coolgardie has been examined in some considerable detail. The geological features of this area are marked by a mass of intrusive granite on the West, succeeded by a belt of hornblende and talcose schists, the whole being intersected by dykes of both basic and acidic rocks. The most extensive area of granite is that which extends from the Coolgardie-Menzies and Coolgardie-Norseman telegraph lines to a point some three or four miles to the Westward; on both sides of this the schistose rocks, which are much contorted and altered, dip away from either side of the granite mass. Further to the South-Westward, and about three miles West of Londonderry, is another granite mass of a somewhat slightly different character. The granite has been penetrated to a depth of 3,000 feet by a diamond drill put down on the Gnarlbine Road, about two miles South-West of the town, on Reserve 3647. The acid eruptive rocks, which, as a rule, follow the strike of the schists, in all probability emanate from the main granite mass, as cases occur in which a gradual passage from the latter can be identified. The dykes seldom exceed twelve feet in thickness. Quartz reefs are often intimately associated with the acidic dykes, and in some cases the latter gradually pass into pure quartz at their extremities. As a rule, these quartz veins are non-auriferous. Certain black or dark banded rocks, of somewhat obscure origin, are invariably found in intimate connection with the felsite dykes. In certain portions of the field they bear a marked resemblance to highly metamorphosed sedimentary beds, to which they may eventually be referred. These black slates (?) exhibit an almost perfect slaty cleavage and texture; they are often elaborately puckered. The banded rocks are not confined to the schists, but appear to traverse the large masses of basic rocks, and intersect the dykes at all angles.

The schistose rocks which are hornblendic, or occasionally talcose, seem to result from the surface weathering of amphibolites. The general strike varies from North 20° West and South 20° East to North 20° East and South 20° West, the dip being from 30° to 60° to the East; more rarely the beds dip West, but such is of local occurrence.

The diorites and andesites form both bosses and dykes, and are found invading both the granite and the schist. So far as observations have been carried it seems that the diorites are of older date than the andesites, as cases occur in which the latter are seen traversing the diorites.

In certain portions of the field, both the granite and schistose rocks are covered with a variable thickness of their own weathered *débris* and other superficial deposits. These superficial deposits extend over a very large portion of Coolgardie; they vary in thickness from a few inches up to several hundreds of feet, as in Rollo's Bore.

Ancient water channels exist in the vicinity of Coolgardie. About eight miles from the township, one of these has been pierced by a bore to a depth of 162 feet. This deposit has been utilised

as a source of the water supplied to Coolgardie by the Hampton Plains Company. The following is a section of the strata pierced :—

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Clay (with ironstone gravel) ...	27	0	...	
Fine sand	30	0	27	0
Coarse yellow (water bearing) ...	...		...	
Sand	43	0	57	0
Clay	4	0	100	0
Sand-wash	11	0	104	0
Kaolin (?)	8	0	115	0
Bed-rock (nature undetermined)...	39	0	123	0
Total ...	**162**	**0**	**162**	**0**

The water struck in this bore rose to some considerable height above the level at which it was first met with.

In some portions of Coolgardie there occurs, resting on the denuded granite surface, a thin bed of cement of the type occurring at Kanowna and the 25-Mile. What now remains of this cement occurs in every case at levels between 1,380 and 1,460 feet above sea level; showing that the deposit has a somewhat uniform altitude. The average thickness of the cement does not exceed 3 feet, and, although auriferous, it has not, up to the present, proved to be payable.

The geological age of the alluvial deposits is somewhat conjectural, as they have, with one or two exceptions, proved to be unfossiliferous. There are reasonable grounds for believing that some, at any rate, are of late Tertiary age.

The gold obtained from Coolgardie has been derived from three principal sources, viz., alluvial deposits, lode formations, and quartz reefs. The gold from the recent superficial deposits presents all the usual characters. Unfortunately there are no data available by which the amount of alluvial gold obtained from the Coolgardie Goldfield can be deduced. The "lode formations," as a rule, consist of schistose rocks traversed by a network of quartz leaders; the formations appear to possess no sharply defined boundaries, unless in exceptional cases; the limits of the deposits being defined by purely technical considerations. A great deal of gold seems to have been derived from these formations; but owing to the way the returns are supplied, it has not been possible to separate the yield of the formations from that of the quartz reefs proper. The quartz reefs trend generally North and South, and have a dip of from 60° to 80° to the East.

Many of the quartz reefs in the neighbourhood of Coolgardie stand up from the surface like walls of masonry, 15 or 20 feet high, having resisted

the denuding action of the atmosphere better than the enclosing country rocks.*

There are two distinct varieties of reefs, one closely resembling the lode formations and occurring in large lenticular patches, often forming pronounced outcrops on the surface, and the other of the true fissure type. Of the first class, the reefs on Bayley's Reward Claim, and the Big Blow Mining Lease, No. 35, are the best examples, whilst Sherlaw's Perseverance, and Burbank's Birthday Gift Mining Lease, No. 3252, are examples of the second class. At the deeper levels the quartz reefs usually carry arsenical and iron pyrites.

The gold is not evenly distributed throughout the reefs but sometimes occurs in irregular patches, one of which, Bayley's, has yielded several thousands of ounces from a very small area. The gold, at times, occurs in shoots, but so far no observations have been recorded as to either their direction or strike.

Kunanalling.—The mining district of Kunanalling (the 25-Mile) has long been noted for its auriferous cement deposits; these have been extensively worked and have proved fairly rich in gold.

The cement at the 25-Mile is of similar character and origin to that at Kanowna. The deposit, which follows a serpentinous course—an old creek—along an eroded granite surface, has been followed for over a mile and a-half; though there are frequent breaks, due in all probability to erosion. The floor upon which the deposits rest is a biotite-granite, which has been much decomposed; the results of erosion are strongly marked by the numerous pot holes and deep gutters. The deposits consist of rounded and sub-angular fragments of quartz of all sizes, cemented together by a ferruginous silicate of alumina in varying proportions. Where the cementing material is not quite so abundant, the grains are usually of a finer or more even texture, having the appearance of a sand-stone so soft as to crumble easily in the hand. In places the cement is overlaid by ironstone gravels which are sometimes separated by a thin layer of pure white kaolin.

The ironstone gravels and kaolin are said to contain small quantities of gold, though not payable. The payable gold, almost without exception, occurs in the cementing material. The richest portions of the deposit have been found where the coarser material was lying on the bottom, and especially where it had gathered on the lower side of some of the larger pot holes.

There seems little doubt that the gold has been deposited mechanically, though a certain quantity may have been added from solution. The ultimate derivation of the gold is from the veins and reefs occurring in the vicinity.

* The Geology and Mineral Deposits of Portions of Western Australia. E. F. Pitmann. Records Geol Survey of N.S.W. 1898. Vol. VI. Pt. I., p. 6.

The quantity of gold derived from these deposits, so far as the official returns show, is, up to the end of 1899, as follows:—

Date.	Quantity of Stone Crushed.			Yield of Gold.					
				Total Yield.			Rate per ton.		
	tons	cwt.	qrs.	ozs.	dwts.	grs.	ozs.	dwts.	grs.
1897	5,397	0	0	7,363	0	0	1	7	6
1898	3,309	10	0	3,038	18	17	0	18	8
1899	6,962	0	0	3,758	18	4	0	10	19
Totals ...	**15,668**	**10**	**0**	**14,160**	**16**	**21**	**0**	**18**	**1**

The following table gives the production of gold from the Coolgardie Goldfield:—

Yield of the Coolgardie Goldfield.

Year.	Ore crushed.			Yield of Gold therefrom.			Gold exported.			Remarks.
	tons	cwt.	qrs.	ozs.	dwts.	grs.	ozs.	dwt.	grs.	*a*. Details not available. *b*. Included with Yilgarn prior to 5th April, 1894. *c*. Includes 236ozs. 17dwts. of dollied and specimens. *d*. Includes 1,158ozs. 19dwts. 3grs. of dollied and specimens, and 52ozs. 14dwt. 7grs. of alluvial. *e*. Includes 1,713ozs. 10dwt. 19grs. of dollied and specimens, and 1,562ozs. 18dwts. 22grs. of alluvial.
1894							*b* 105,329	16	11	
1895	*a* 31,419	13	0	*a* 66,691	14	23	125,105	18	18	
1896							69,135	3	16	
1897	56,183	19	1	*c* 72,281	9	22	104,306	7	9	
1898	107,622	7	3	*d* 99,672	16	18	127,227	1	8	
1899	154,679	2	3	*e* 126,144	6	9	113,558	16	20	
Total	**349,905**	**2**	**3**	**364,790**	**8**	**0**	**644,663**	**4**	**10**	

Broad Arrow Goldfield.

The Broad Arrow Field embraces an area of 590 square miles, and is defined by the authorities as being:—

Bounded by lines starting from Survey Station R3; thence East about 17 miles 30 chains to a point North of the most Northerly corner of the East Coolgardie Goldfield; thence South about 29 miles 70 chains to that corner; thence about 234° 51′ 14½ miles to the 40-mile post on part of the Eastern boundary of the Coolgardie Goldfield; thence about 324° 46′ 9 miles 32 chains 44 links; thence North 30 miles 47 chains 56 links to the starting point.

The most Northerly mining centre of the field is Bardoc, and an area of about 40 square miles has been geologically mapped by

Mr. Blatchford, the Assistant Geologist. According to this officer's researches, it seems that the geological features and mode of occurrence of the ore deposits bear a strong similarity to the Coolgardie Goldfield. By far the larger portion of the field is covered with a varying thickness of loose, incoherent material, and the ubiquitous nodular ironstone beds.

These latter usually cover the higher ground in isolated patches, which at one time were virtually continuous. Where any good section is visible, it is invariably found that the ironstone gradually merges into the underlying rocks, and the iron oxides of the basic rock-forming minerals gradually replace the less basic constituents. These ferruginous beds have not yet proved auriferous.

The hornblendic rocks form by far the largest area of any of the rocks exposed at the surface.

A few isolated outcrops of a coarse-grained micaceous granite make their appearance from beneath the superficial deposits.

An important feature of the field are those narrow dykes (?) of some acidic rock—the percentage of silica in which, as determined in the laboratory, fluctuates between 51 to 68 per cent. There are, however, good grounds for believing that some, at any rate, of these dykes (?) are, in reality, contemporaneous lava flows, and that some of the enclosing rocks, almost universally mapped as basic rocks, are merely transmuted sedimentary rocks.

The gold produced from this centre has been derived from three sources, viz.:—Alluvial deposits, lode formations, and quartz reefs. The gold from the alluvial deposits presents all the usual characters. The lodes, so far as observations have been carried, are usually banded, and practically distinguishable from the country rock only by their auriferous character. The quartz reefs, which invariably occur in intimate association with the acid eruptive dykes, are of two distinct varieties. The first occur as lenticular patches, from which small quartz veins emanate in all directions. These branching veins appear to be the richer.

The second type are those banded rocks which consist of alternating layers of crypto-crystalline quartz and hematite. The proportion of oxides of iron varies from a practically pure hematite to a quartz rock, through which such small quantities of hematite are disseminated as to give it a brown or bluish appearance. These banded rocks seem to have been permeated with secondary silica, which has also penetrated the surrounding rocks. Although these banded quartzites have proved auriferous, none of them have so far shown themselves to be payable; in the circumstance that these banded quartz rocks are a possible source of gold, they are identical with the quartzites of Peak Hill (to which reference has been made on an earlier page), and of Mount Margaret.

The deposits of Bardoc have yielded 8,424ozs. of gold by the crushing of 11,710 tons of ore: being at the rate of 14dwts. per ton.

This gold has been derived almost exclusively from quartz reefs of the first type.

Our knowledge of the ore deposits in the more immediate vicinity of Broad Arrow is somewhat meagre. According to Mr. H. P. Woodward* there are two principal lines of lode in the neighbourhood of Broad Arrow; the two which have a more or less North-Westerly trend are about a third of a mile apart. These, in all probability, are the Southerly continuation of some of those lodes which have been mapped in the Bardoc neighbourhood.

A good deal of prospecting seems to have been carried out in the search for deep leads in the vicinity of Bardoc. Despite the fact that some of the claims got good prospects, it is asserted that the true course of the lead had not been determined. Only 114ozs. of alluvial gold have been officially reported from the Broad Arrow Field for the year 1899.

The following table gives the yield of the Broad Arrow Goldfield:—

Yield of the Broad Arrow Goldfield.

Year.	Ore crushed.			Yield of Gold therefrom.			Gold exported.			Remarks.
	tons	cwts.	qrs.	ozs.	dwts.	grs.	ozs.	dwts.	grs.	*a.* Complete details not available.
1896	*a* 1,536	4	0	*b* 9,129	5	0	*a*			*b.* Complete details not available, but includes 250 ozs. from unknown tons.
1897	19,636	6	0	*c* 14,464	10	18	*d* 4,159	5	9	*c.* Includes 27ozs. 4dwts. of dollied and specimens.
1898	32,004	1	1	*e* 27,726	8	14	24,631	8	20	*d.* No details available prior to 1st September, 1897.
1899	60,032	8	0	*f* 48,309	2	1	36,020	15	19	*e.* Includes 1,754oz. 5grs. of dollied and specimens. *f.* Includes 240ozs. 3dwts. 15grs. of dollied and specimens, and 114ozs. 4dwts. 3grs. of alluvial.
Total	**113,208**	**19**	**1**	**99,629**	**6**	**9**	**64,811**	**10**	**0**	

East Coolgardie Goldfield.

This comparatively small field, the most productive in Australia, embraces an area of 632 square miles; it is defined by the authorities as being:—

Bounded by lines starting from a mile post on the Eastern boundary of the Coolgardie Goldfield, 40 miles Southerly from Survey Station R3, and extending 144° 46′ 26 miles 62 chains 37 links along a surveyed line to the North-East corner of Location 53; thence Southerly along the Eastern boundary of Location 53 and the Western boundary of Location 51 to the South-West corner of Location 51; thence along the boundaries of that Location Easterly 119 chains 87 links, Northerly 60 chains, Easterly 160 chains to a point on the Western boundaries of Location 48, Southerly 564 chains 87 links, Easterly 443 chains 91 links to the South-East corner of that Location; thence Easterly about 7 miles 65 chains to a point South of the

* Mining Handbook. Perth: By Authority, 1895; p. 110.

South-East corner of Location 45; thence North to the said corner; thence North along the Eastern boundary of Location 45 4 miles to its North-East corner; thence about 342° 10′ about 1 mile 64 chains to the South-East corner of Location 44; thence along the Eastern boundary of Location 44 to its North-East corner; thence about 321° 35′ about 30 miles 53 chains to a point bearing about 54° 50′ from the 40-mile post on the Eastern boundary of the Coolgardie Goldfield; thence about 234° 50′ about 14½ miles to the starting point.

Kalgoorlie, the official centre of the East Coolgardie Goldfield, the most productive field in Australasia or the British Colonies, was originally named Hannan's, after the original discoverer, Patrick Hannan.

The principal topographical feature of the field consists of a low broken range, of which Mount Charlotte, 1,378 feet above sea-level, forms the highest summit, and which trends generally North-North-West from the head of Hannan's Lake. This line of comparatively low hills diminishes in altitude from Mount Charlotte to a mere ridge, which gradually merges into the flat ground surrounding the lake, and forms the main water-parting of the district. To the Eastward, the country extends in a wide gently sloping valley, with a Southerly fall, flanked by a line of low hills, some six or seven miles distant; to the Westward is another valley of about two miles in width.

By far the larger portion of the field is covered with a mantle of reddish loamy soil, and other superficial accumulations of variable thickness. These superficial deposits consist of ironstone gravels and cement, passing in certain isolated localities into practically pure brown hematite. Some of these surface deposits have proved to be highly auriferous in places.

The rocks of the field consist of talc, mica, hornblende, and chlorite schists, intersected by dykes and masses of certain igneous rocks, the exact nature of which has not yet been determined. At the surface these rocks have been decomposed into a more or less mottled clay. Mining operations have shown that this zone of alteration extends to very variable depths, fluctuating between 50 and 400 feet, which latter, however, is exceptional. The following is an analysis, made in the Survey Laboratory of one of the oxidised schists, from the 50ft. level in the Great Boulder Perseverance G.M.:—

	Water, H_2O hygroscopic	0·730
	„ „ combined	5·951
Soluble in hydrochloric acid	Ferrous oxide, FeO	1·600
	Ferric oxide, Fe_2O_3	36·285
	Alumina, Al_2O_3	3·120
	Manganese dioxide, MnO_2	0·969
	Sulphate of lime, $CaSO_4$	Trace
Insoluble	Silica, SiO_2	39·760
	Alumina, Al_2O_3	11·485
	Ferrous oxide, FeO	Trace
	Magnesia, MgO	Trace
		99·900

Gold ... ... 5ozs. 2dwts. 8grs. per ton
Silver ... ... 1oz. 14dwts. 16grs. per ton

Below the level beyond which decomposition does not extend, the strata pass gradually downwards into a very fine grained rock, the exact nature and origin of which is at present somewhat obscure. The composition of a characteristic sample of one of the undecomposed schists, carrying tellurides of gold, from the 300ft. level of the Lake View Consols G.M., was found, on analysis in the official laboratory, to be as follows:—

	Water, H_2O Hygroscopic	0·402
	,, ,, Combined	1·809
Soluble in hydro-chloric acid	Carbonate of lime, $CaCo_3$	10·882
	,, magnesia, $MgCo_3$	6·315
	,, iron, $FeCO_3$	1·553
	Ferrous oxide, FeO	1·360
	Ferric oxide, Fe_2O_3	1·541
	Alumina, Al_2O_3	1·326
	Manganese protoxide, MnO	Trace
	Phosphoric acid	Trace
Soluble in nitric acid	Iron, Fe	3·990
	Sulphur, S	4·417
	Tellurium, Te	Trace
Insoluble	Silica, SiO_2	51·271
	Titanic oxide, TiO_2	0·226
	Alumina, Al_2O_3	12·519
	Ferrous oxide, FeO	0·311
	Lime, CaO	0·313
	Magnesia, MgO	1·159
	Alkalies and loss	0·606
		100·000

Gold ... ... 9ozs. 12dwts. 18grs. per ton.
Silver ... ... 6ozs. 7dwts. 8grs. ,,

Some of the Kalgoorlie rocks have been microscopically examined at the hands of Mr. Card, the Petrographer to the Geological Survey of New South Wales, and, as a result of the chemical and microscopical investigations, this gentleman thus summarises his deductions:—

(1). The country rock is the same throughout the field; broadly speaking, the description of one would apply to the other. They all agree in containing titaniferous iron ore, quartz, and mica. (2.) The ore bodies are simply more highly altered country rock. It will be noted that the titaniferous iron ore and primary quartz occur in the ore, as in the country, with a tendency, however, to granulation. (3.) The rock is of igneous origin, and in all probability of great geological antiquity. The pegmatitic structure and mineralogical constitution leave no doubt as to the origin, and the extreme alteration, of a deep-seated character, proves the antiquity. Titaniferous iron ore is thus found (. . . Great Boulder Mine) completely converted into opaque yellowish-white products; very much of the original silicates has been replaced by seicitic material, and the primary quartz has been split up into groups of fragments or completely absorbed. (4.) The country rock affords but very little indication of shattering or crushing; the alteration it has undergone has been chemical rather than cataclastic—effected under the influence of high

temperature and steady pressure. Subsequently to this deep-seated chemical alteration, mountain-making forces made themselves felt along certain directions, crushing the rocks to some extent, and (more particularly) inducing foliation in the sericite, and consequently a certain amount of jessility in the rock. This effect has seldom been sufficiently pronounced to produce a general foliation of the whole, and convert it into a true schist. The contact metamorphism that would result from the late intrusions if, as seems probable, there were more than one, must not be overlooked. (5.) The telluride of gold, together with the associated carbonates of lime and magnesia, and the secondary quartz, have been introduced into the ore body by solutions which found ready access along the planes of parting produced by the incipient foliation. That much of the chlorite has been introduced in the same way seems probable from its frequent occurrence in wavy bands; alumina is also present in the mine waters."*

The gold of Kalgoorlie is found both in lodes and in superficial accumulations, which owe their origin to the disintegration of the lodes, etc. These superficial accumulations have, so far as official records show, produced only 1,229ozs. of gold; the lodes however are by far the most important, for they have turned out 1,717,298ozs. of gold since the first discovery of the field.

The lodes of Kalgoorlie consist of a series of almost vertical banded schistose formations (merely country rock more or less altered by dynamic changes), which have a general trend of from North 30° West to North 50° West. These deposits are lenticular in habit, the lenses being often of great length. Instances occur which go to prove that some of these may reach over half-a-mile in length. At times, however, the lateral continuity of the lenses is interrupted by faults of very variable downthrow. As a general rule the ore deposits have no well-defined walls, but seem to pass insensibly into the surrounding rock. The lodes are often traversed by a network of quartz veins, which ramify in all directions.

There is abundant evidence attesting the fact that the rocks have been subjected to profound dynamic phenomena, which has resulted in the production of lines of weakness along which mineral bearing solutions have found a comparatively easy passage. The width of the ore bodies reaches as much as 80 feet in places.

The gold occurs free as tellurides and as auriferous pyrrhotite. The free gold presents such characters as point to its having been derived from the oxidation of the tellurium-bearing minerals; the decomposition of the auriferous pyrites may also be the source of some portion of it. The free gold often occurs in spongy or cellular masses of varying sizes and shapes, and is at times coated with a dull clayey ferruginous material of a yellow colour, known as "mustard gold," which may represent an oxidised form of tellurium. The tellurides of gold occur chiefly as Calaverite. The

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* Geo. W. Card. Notes on the Country Rock of the Kalgoorlie Goldfield. Rec. Geol. Surv., N.S.W. Vol. VI. part 1, 1898. Sydney: By Authority; pp. 38-39.

following analyses of the telluride from this district have been made :—

Chemical Analyses of Tellurides from Kalgoorlie.

	I.	II.	III.	IV.	V.
Tellurium, Te	59·69	56·64	57·27	49·48	37·26
Gold, Au	38·70	41·76	41·37	Trace.	20·72
Silver, Ag	1·66	0·80	0·58	0·12	30·98
Mercury, Hg	...	...	...	50·40	10·86
Sulphur, S	0·09	...	...	...	0·13
Copper, Cu	0·21	...	...	...	0·05
Iron, Fe	0·18	...	...	...	...
Lead, Pl	Trace.	...	...	...	...
Bismuth, Bi	Trace.	...	...	...	...
Zinc, Zn	Trace.	...	...	...	...
Total	100·53	99·20	99·22	100·00	100·00
Sp. Gr. ...	...	...	...	9·21	8·71

I.—Calaverite: Lake View Consols Mine—Analyst, G. J. Rogers.
II.—Calaverite: Australia Mine—Analyst, J. C. H. Mingaye.
III.—Calaverite: Australia Mine—Analyst, E. S. Simpson.
IV.—Coloradoite: Australia Mine—E. S. Simpson.
V.—Kalgoorlite: Lake View and Boulder Junction Mine—Analyst, J. C. H. Mingaye.

The value of the different ore deposits of the East Coolgardie Field naturally vary considerably; from a few pennyweights up to as much as 61oz. to the ton of ore treated. The ore treated, according to the official statistics, yielded during the years previous to 1898, gold at the rate of 2oz. 13dwts. 11grs. per ton; during 1898, 1oz. 10dwts. 22grs. per ton; during 1899, 1oz. 16dwts. 15grs. per ton; while the average of all the ore crushed is about 1oz. 18dwts. 8grs. per ton.

The following table shows the yield of the East Coolgardie Field :—

Yield of the East Coolgardie Goldfield.

Year.	Ore crushed.			Yield of Gold therefrom.			Gold exported.			Remarks.
	tons.	cwt.	qrs.	ozs	dwts.	grs.	ozs.	dwts.	grs.	*a.* Complete details not available.
1896	*a* 43,270	18	0	*b* 143,072	13	12	*c* 85,287	1	7	*b.* Complete details not available, but includes 500ozs. from unknown tons.
1897	121,321	3	1	*d* 297,520	2	18	300,037	4	18	*c.* Included with Coolgardie prior to 1st May, 1896.
1898	264,324	15	1	*e* 422,391	17	3	450,312	5	10	*d.* Includes 46oz. 3dwt. of dollied and specimens. *e.* Includes 148ozs. of dollied and specimens.
1899	466,759	1	3	*f* 855,404	17	7	890,566	7	11	*f.* Includes 29ozs. 11 dwts. 3grs. of dollied and specimens, and 590ozs. 5dwts. 2grs. of alluvial.
Total	**895,675**	**18**	**1**	**1,718,389**	**10**	**16**	**1,726,202**	**18**	**22**	

North-East Coolgardie Goldfield.

This goldfield embraces an area of 21,542 square miles, and according to the authorities it is comprised by :—

Lines starting from a point situate about 17 miles 30 chains east of Survey Station R 3; thence South about 29 miles 70 chains to the most Northerly corner of the East Coolgardie Goldfield: thence about 141° 35′ about 30 miles 53 chains to the North-East corner of Location 44; thence along the Eastern boundary of that location to its South-East corner; thence about 162° 10′ about 1 mile 64 chains to the North-East corner of Location 45; thence along the Eastern boundary of that location to its South-East corner; thence South to a point 7 miles 65 chains East from the South-East corner of Location 48: thence East about 27 miles 15 chains: thence South about 48 miles to the South-East corner of the Coolgardie Goldfield; thence East to the 125th meridan of East longitude: thence North along that meridan to a point East of Survey Station R 3 aforesaid; thence West to starting point.

For administrative purposes the field is divided into three districts:—Kanowna (White Feather), Bulong (I.O.U.), and Kurnalpi.

Kanowna.—The fundamental rocks of the Kanowna district are chlorite, talcose, and serpentinous schists, invaded by dykes of acid eruptive rocks, which have a prevailing North-Easterly strike and an Easterly dip. The schists, so far as has been disclosed by mining operations, are all in an advanced stage of decomposition. They have proved to be highly auriferous in places. The granitic rocks which contain gold in appreciable quantity are reticulated by interlacing quartz veins, which are also auriferous; these appear to have been prospected with considerable success.

According to H. P. Woodward* a large quartz reef from 3 feet to 6 feet in width, and running for miles in a more or less North and South direction, forms a prominent feature in the district. Several other parallel quartz reefs and cross reefs occur, and they are all situated to the East of the main reef. The gold shoots in the main reef contain the metal in a coarse form, and carry, besides, a considerable quantity of fine gold not visible in the stone. In the lower levels the gold is associated with pyrites (especially chalcopyrite) and mispickel.

The principal interest, however, at Kanowna at present attaches to the alluvial leads, which have been extensively worked. The most prominent of these is the North Lead, which lies in a natural depression which has been traced from the Cemetery to G.M.L. 918. The North Lead lies in an old watercourse carved out of the older rocks, and has been proved to be not merely a simple isolated run of auriferous gravel, but part of a series of old stream deposits, which took their rise in the comparatively elevated ground to the East and flowed in a general Westerly direction.

The Lead trends generally Northwards as far as the G.M.L. 923, when its course is suddenly deflected to the East. It is joined near the Birthday Gift Claim by what is known as Wilson's

* *Loc. Cit.*

Gully Lead, which enters from the South. Some distance below the junction the North Lead loses itself in an extensive flat, which may prove to be merely a lake-like expansion of its channel. The connection of the Q.E.D. Lead on the North, although it trends in such a direction as to fall into the North Lead, has not yet been definitely proved. All things point to such a connection, though it may be that the lead has been lost by denudation.

The width of the old stream varies from 2 to 80 feet, having an average, according to Departmental observations, of about 15 feet. The thickness of the deposit in the old channel varies from a few inches up to as much as 90 feet. The fall of the lead is about at the rate of 40 feet to the mile.

The deposits filling the old watercourse naturally vary somewhat in different portions. They consist first of a variable thickness of surface loam, etc., succeeded by ironstone gravels partially cemented in places by kaolin and oxide of iron into solid rock. Beneath this lies a bed or beds of practically pure kaolin ("pug"), and a varying thickness of a pebbly quartz wash. The wash contains rounded and subangular pebbles of quartz, which, in the upper portion of the deposit, is often associated with kaolin and sand. This quartz wash is cemented by secondary silica into a hard, compact rock, which, in hand specimens, might easily be mistaken for quartzite.

So far as mining operations have, up to the present, been carried, it would seem that the whole of the detrital deposits have not proved auriferous. Most of the alluvial gold has been won from the pebbly quartz wash, although the overlying kaolin ("pug") and ironstone gravels have also yielded a certain quantity.

The ultimate derivation of the gold in the North Lead is from the quartz veins and lodes (upon which the wash directly reposes in places) by which the crystalline rocks are traversed; for the gold is not exclusively in the form of grains, scales, etc., but is found occurring in the quartz pebbles themselves.

In addition to what may be called detrital gold there is another massive, arborescent, or coarsely crystalline form which occurs, filling certain irregular cracks, and covering cleavage planes or shrinkage cracks, so as to present the appearance of painted surfaces.

The mode of occurrence, associations, and character of this gold all point to a secondary origin; and it is of importance to note that this, what may be called secondary gold, has been deposited from solution, not only in the alluvium and other superficial deposits, but also in the zone of decomposition of the bed-rock. These secondary forms, which result in the superficial enrichment of many auriferous deposits, are a common feature in the mineral fields of the Colony.

Of the age of the North Lead there is no evidence available at the present time. Owing to the fact that at a date subsequent to

its formation a sufficient length of time has elapsed to allow of the lead being sealed up by great accumulations of superficial deposits (some of which have been consolidated into solid rock), may point to considerable geological antiquity.

It is impossible to arrive at the gold yield of the portion of Kanowna traversed by the old watercourse, owing to there being no separate returns furnished by the claim holders on the North Lead. The returns, which are appended, show that up to the end of 1899, the lodes from Kanowna have yielded 68,815ozs. of gold by crushing 72,939 tons of ore. The alluvial deposits, the gravels, have yielded 90,652ozs. of gold, and 97,081 tons of cement crushed have been responsible for 139,023ozs. From these data it will be seen that the alluvial deposits turned out 77 per cent. of the total production.

Tables showing the Gold production of Kanowna.

I.—LODES.

Year.	Ore crushed.	Total Yield.	Rate per ton.
	tons. cwts. qrs.	ozs. dwts. grs.	ozs. dwts. grs.
Previous to 1898 ...	27,365 11 0	28,243 15 11	1 0 15
1898	24,838 2 0	20,892 0 0	0 16 19
1899	20,735 10 0	19,680 0 14	0 18 23
Total	**72,939 3 0**	**68,815 16 1**	**0 18 20**

II.—ALLUVIAL DEPOSITS.

(*a.*) *Gravels.*

Previous to 1898 ..	... ...	10,611 18 10	
1898	... ...	63,548 0 10	
1899	... ...	17,492 15 2	
Total	... ...	**91,652 13 22**	

(*b.*) *Cement.*

Previous to 1898	*	*	
1898	45,983 4 2	68,183 10 22	1 9 15
1899	51,098 14 2	71,839 18 11	1 8 2
Total	**97,081 19 0**	**140,023 5 9**	**1 8 20**

* No data.

There are no data available by which the average fineness of the gold from the North Lead can be obtained.

That many other similar leads probably exist is obvious from the geological structure of the district, though, owing to the completeness by which they have been sealed up by the more recent accumulations, they can only be tapped by a judicious system of prospecting.

It is desirable that the other leads in the district be accurately mapped, contour surveys made, and every accessible shaft carefully examined, after which it should be possible to throw considerable light upon the probable trend of the old stream courses; for so long as these continue there is always a chance of payable deposits occurring, though they are hardly likely to be discovered without many failures.

The mining centre of Mulgarrie lies about 20 miles North-East of Kanowna. The strata consist chiefly of hornblendic rocks, intersected by acidic dykes, the whole being overlaid in places by recent superficial accumulations, which latter attain a thickness of over 100 feet in places.

The hornblendic rocks are usually in a more or less highly decomposed state, which tends to conceal their true character. The acidic dykes form long narrow bands trending usually North-West and South-East, and with a high dip to the East. These dykes appear to be younger than the schistose rocks. An isolated patch of a hornblende granite outcrops in one portion of the district, but its relation to the surrounding rocks is far from clear. A prominent feature of the field are those banded siliceous rocks which bear a marked resemblance to the quartzites of the Murchison. The rocks (in reality hematitic quartzites) are composed of alternations of quartzite and brown hematite and a fine grained banded practically pure quartz rock. This rock is often reticulated with quartz veins.

The quartz reefs of the district, which are intimately associated with the banded quartzites, have a prevailing strike of North-West, with an underlie to either the East or West.

Hayes' New Find is situated near the Northern boundary of the Kanowna district, distant 24 miles North-East of Kanowna, and about 30 miles due East from Bardoc.

A very large portion of the surface of the field is covered with red loam. The staple formation of the field consists of serpentinous schists, which have a prevailing strike of from North 15 to 20 degrees West. As these schists are followed underground their schistosity is less apparent, and disappears entirely at about 200 feet.

A large portion of the field is made up of a quartz porphyry which seems to invade the schists. The rock has undergone extensive decomposition at the surface, and, in places, would be best described as kaolin. Some of the weathered portions of the porphyry exhibit a schistose structure, which is coincident with that by which the serpentinous beds are traversed. The porphyry is intersected by certain basic dykes, the exact nature of which it is impossible, owing to the extensive decomposition, to define.

The higher portions of the district are covered by the remains of a once continuous sedimentary deposit and ironstone gravels. Some of these sedimentary beds are really quartzites, others are of

a softer sandy nature; neither, however, have proved to be auriferous.

Bulong.—The Bulong or I.O.U. Mining District never has been the subject of geological examination, so that the information is far from complete. The country rock is described by S. Göczel, a former member of the staff, as being partly diorite and partly diabase, both having been much subject to decomposition. A large North and South reef is said to form an important feature; two miles to the West of this is a stretch of country, about two miles long, in which several gold-bearing lodes occur.

On the ground held by the Mystery Gold Mining Company large quantities of gold have been obtained from the superficial covering of a ferruginous deposit (laterite) which covers such extensive areas in the Colony. The deposit is described as a gritty limonite, interbedded with clayey ironstone.

The alluvial deposits of Bulong, some of which have been worked at a depth of over 100 feet, have yielded, up to the close of 1899, 15,390ozs. of gold. Several leads have been worked, but as they have never been geologically mapped, details in connection with them are wanting.

Kurnalpi.—Of the Kurnalpi District practically no information is available. The alluvial deposits, however, have yielded up to the close of 1899, 5,782ozs. of gold.

The following table gives the production of the North-East Coolgardie Goldfield:—

Yield of the North-East Coolgardie Goldfield.

Year.	Ore crushed.			Yield of Gold therefrom.			Gold exported.			Remarks.
	tons.	cwts.	qrs.	ozs.	dwts.	grs.	ozs	dwts.	grs.	*a.* Complete details not available.
1896	*a* 5,682	6	0	*b* 8,975	19	0	*c* 4,113	3	15	*b.* Complete details not available, but includes 150ozs. of dollied and specimens.
1897	28,546	5	0	*d* 40,453	1	21	32,905	16	8	*c.* Prior to 1st May, 1898, included with Coolgardie.
1898	80,095	16	2	*e* 170,441	14	18	125,240	9	19	*d.* Includes 866oz. 4dwts. 12grs. dollied and specimens, and 10,917oz. 18 dwts. 22grs. of alluvial.
1899	82,736	6	0	*f* 112,845	13	21	64,470	5	14	*e.* Includes 1,115oz. 11 dwts. 12grs. of dollied and specimens, and 69,069oz. 15dwts. 6grs. of alluvial.
Total	**197,060**	**13**	**2**	**332,716**	**9**	**12**	**226,729**	**15**	**8**	*f.* Includes 1,648oz. 17 dwts. 11grs. of dollied and specimens and 34,527oz. 15dwts. 22grs. of alluvial.

Dundas Goldfield.

This field, the most Southerly of the Eastern fields, embraces an area of 17,848 square miles, which, according to the authorities, is:—

Bounded on the North by an East and West line passing through the summit of a granite rock near the 50-Mile Soak, on the Dundas and Lake Lefroy Road; on the East by a North and South line through a point 52 miles East of Mount Ridley; on the South by an East and West line passing through the summit of Mount Ridley; on the West by the production South of the Western boundary of the Coolgardie Goldfield.

It seems that Mr. Moir, of Fanny's Cove, was the first to detect gold in the country now embraced by this field. The discovery was made in the alluvium of one of the creeks when this gentleman was engaged in searching for pastoral lands; no effort would appear to have been made to give further attention to the district until some years later, when Mr. Moir organised a prospecting party, which, however, was not successful. About the same time further prospecting was carried out by other parties which resulted in the discovery of a rich reef called the "May Bell" and another called the "Scotia."

The staple geological feature of the Dundas field consists of the foliated granites or gneisses associated with certain schistose rocks, hornblende, mica, and chlorite schists, amphibolites, hematite-bearing quartzites, felsitic dykes, and other igneous rocks.

A series of quartz reefs, parallel to these dykes, trend in a general North-North-Easterly direction: some of these are in intimate association with certain of the hematite-bearing quartzites of the type alluded to on a previous page.

The surface of a large portion of the district is covered with ironstone gravel and conglomerate which effectually conceals the underlying rocks, and renders prospecting exceptionally difficult.

The gold in the reefs is sometimes associated with native bismuth, and was recorded by Mr. S. Göczel in 1893.

It does not appear that Dundas will attain any prominence as an alluvial field, although as a reefing district its structural features are highly favourable.

The following table gives the yield of the Dundas field:—

Yield of the Dundas Goldfield.

Year.	Ore crushed.	Yield of Gold therefrom.	Gold exported.	Remarks.
	tons cwt. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	
1893	a 3,020 0 0 (1893–1896)	a 3,983 10 0 (1893–1896)	147 19 11	a. Details not available.
1894			228 7 12	b. Includes 77ozs. 10dwts. of dollied and specimens.
1895			241 18 2	c. Includes 5ozs. 12dwts. of dollied and specimens.
1896			4,350 6 6	d. Includes 146ozs. 3dwts. 14grs. of dollied and specimens, and 142ozs. 15dwts. 1gr. of alluvial.
1897	16,882 19 2	b 19,279 18 10	19,310 16 7	
1898	30,928 7 0	c 36,798 9 14	32,031 16 6	
1899	59,470 16 0	d 44,356 15 18	44,691 6 11	
Total	**110,302 2 2**	**104,418 13 18**	**101,002 10 7**	

Donnybrook Goldfield.

This little Goldfield is situated between Geographe Bay and the Greenbushes Tinfield. The authorities define its boundaries as follows:—

Starting from the South-Western corner of Reserve 6321 (Covenley Townsite); thence North about 60 chains to the Boyanup-Bridgetown Railway Reserve; thence by the Western boundary of said Railway Reserve in a general North-Westerly direction about 14¼ miles to its intersection with the Eastern boundary of Wellington Location 239; thence North about 10 chains to the left bank of the Preston River; thence by said River in a general North-Easterly direction about 2¼ miles to the North-Eastern corner of Reserve 645A; thence North about 3 miles; thence West about 7 miles to the Eastern boundary of Boyanup-Bridgetown Railway Reserve; thence by said Railway Reserve in a general South-Easterly direction about 3¾ miles to a point North of North-West corner of Wellington Location 836; thence South about 13¼ miles; thence East about 9¼ miles to the point of commencement.

The field has been reported upon by the Assistant Geologist, from whose reports the following details have been extracted.

Donnybrook is situated on the Bunbury and Bridgetown Railway, and is 26 miles South-East of Bunbury and 143 miles by rail from Fremantle. The scene of mining operations is some two miles to the South of the Donnybrook townsite, on a small branch of the Preston River, in the Blackwood Range. Gold would seem to have been first discovered in 1897, by a party of prospectors searching for alluvial gold. Further investigations carried on eventually led to the discovery of auriferous quartz veins, from which most of the gold had originally been shed.

The country, which is extremely hilly and thickly timbered, is for the most part covered with ironstone gravel deposits, which effectually conceals the underlying rocks, except in the gullies and sides of the hills.

The country rocks of the field consist of massive hornblende and gnessic granites intersected by a belt of hornblende rock trending North and South, and traceable for some considerable distance in a Southerly direction. The width of the belt of dioritic rock varies from a quarter of a mile, though it has never been found to exceed a mile. In hand specimens the rock is found to consist of coarse hornblende crystals associated with more or less decomposed felspars. The Western edge of the dyke has a banded structure, and resembles hornblende schist; in isolated cases it is found occurring as an exceedingly fine grained and exceptionally hard rock. The granite naturally varies considerably in texture and composition, though, as a whole, it is a hornblende granite. In several localities the hornblende is almost entirely replaced by muscovite mica. Epidote is found occurring as a rock-forming mineral in the granite. Recent developments have shown the existence of extensive deposits of sandstone lying beneath the ubiquitous ironstone gravels. These sandstones, which are usually of a light grey colour, are fine grained and of an even

texture. The maximum thickness attained by the sandstones is not less than 150 feet.

The quartz reefs all occur in the granite to the West of the diorite, always in close proximity to the junction of the two rocks. The general strike of the reefs is a little to the West of North and East of South, with a high dip to the East. Mining operations have shown that payable quartz reefs occur in the sandstone as well as in the unaltered granite.

Some of the gold from Donnybrook occurs in the filmy arborescent form, which points to a secondary origin.

From the appended table of the returns showing the yield of Donnybrook it appears that the total output is 579ozs. of gold, of which 32ozs. is alluvial.

Yield of the Donnybrook Goldfield.

Year.	Ore crushed.	Yield of Gold therefrom.	Gold exported.	Remarks.
	tons. cwts. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	
1898	18 0 0	14 13 0	*a*	*a*. No details available prior to 1st March, 1899.
1899	294 16 0	*b* 511 9 18	*a* 309 18 16	*b*. Includes 32ozs. 2dwts. of alluvial.
Total	**312 16 0**	**526 2 18**	**309 18 16**	

CHAPTER IV.

Other Localities at which Gold has been discovered.

Bowes River, Peterwangey Hill, Wongan Hills, Black Boy Hill.

Bowes River.—The banks of the more important watercourses in the Champion Bay District are skirted by a width, more or less great, of recent superficial deposits. It is worthy of note that Mr. F. T. Gregory, writing in 1861, said that "specks of gold have also been obtained by washing the sands in the Bowes River." *

Peterwangey Hill.—A little gold was found in the year 1868 in the alluvium on the North side of Peterwangey Hill, which is situated on the Irwin River, about 63 miles to the Eastward of Geraldton. The gold is in the spurs, which are capped with large deposits of red clay, sand, pipe-clay, and nodular ferruginous claystones. Judging from its highly-waterworn appearance, and the fact that the mineral veins of this locality are not auriferous, it has probably been derived from some old stream bed which passed across this country in a different direction and at a higher level than the existing rivers. Nothing certain can, however, be stated on this point until the district has been examined in detail and all the old watercourses mapped. The rocks here are mostly granite, with diorite dykes, and occasionally quartz reefs of highly crystalline character: but a few miles lower down the river, and also further to the Eastward, the country assumes a more promising aspect for gold, the rocks being more schistose, and containing many nice-looking quartz and ironstone lodes, though none have yet proved to be auriferous. †

Wongan Hills.—The Wongan Hills would seem to have been first reported upon by Mr. H. Y. L. Brown, in the year 1871, who noted that they were "composed of a hard blue metamorphic schist, sometimes micaceous, at others hornblendic, dipping vertically, and striking North and South. It is a representative southwards of the Tallering, Nancarrong, and Blue Mountain series of rocks, and is overlaid by a thick capping of ferruginous sandstone and claystone." ‡

The year 1888 would appear to have seen the first recorded occurrence of gold in the Wongan Hills. The district was visited by Mr. H. P. Woodward, then Government Geologist, from whose pen the following description emanated:—

They (the Wongan Hills) appear from the westward to be two or three isolated peaks, but on approach these are found to be the highest points,

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* On the Geology of Part of Western Australia. Q.T.G.S., London, 1861.

† H. P. Woodward. Mining Handbook. Perth: By Authority, 1895; pp. 115.

‡ On the Geology of the Country passed over from the 21st August to the 17th September, 1871. Perth: By Authority, 1872.

and to form the abrupt termination of a range which runs in a North-East direction. They are flat-topped hills, presenting a bold escarpment to the South-West of about 300 feet above the surrounding clay flats; this face is probably caused by a line of fault, which would also account for the springs near their base. The rocks are metamorphic and crystalline, with veins of radiated actinolite and small quartz veins. They strike North-East and South-West, following the direction of the range, dipping at an angle of 60° to the North-West and making their appearance again in a small hill to the North called the Little Wongan. Granite rocks form the low ridges to the North and South; they are often almost covered by sand or ferruginous conglomerate. The highest peaks of the range are capped by a ferruginous conglomerate, nodular clay ironstone, intermixed with sand or clay, clays and ferruginous sandstones horizontally bedded. These beds also cap the low granite ridge, but occupy many different elevations, owing to the upheaval of the Wongan to the North-East of the fault. The recent deposits are sand, clay, and loam. Of these the sand greatly predominates, forming large plains to the West and North, occasionally interrupted by large salt flats and claypans. The loam forms patches of rich red soil (generally thickly timbered with gimlet wood). There is very little to be seen of the plutonic rocks at the surface. A few small diorite dykes occur in the range, and probably some of the granites at the base of the hills are intrusive. Quartz reefs in this district are quite a rarity. They are small, of a yellow glassy appearance, containing either pyrites or brown hematite and a little gold. They have well-defined walls, dipping at an angle of about 65° in a North-West direction, following the strike of the rocks North-East and South-West. When opened, some very good specimens and prospects, both from the reefs and the casing, were obtained. The size of the reefs is unknown, as, owing to the hard nature of the ground, and to the discovery of many richer reefs at Yilgarn, they were abandoned. *

The country rock of the field consists of hornblende and micaceous schists, which are either vertical or are inclined to the West, and have a general northerly strike. Intersecting these beds are basic dykes, which would seem to be arranged in two series approximately at right angles to each other. The time at my disposal, however, did not admit of mapping the whole of these basic dykes. One basic dyke trends generally North and South; and another, the more conspicuous of the two, has a prevailing strike of North-East and South-West. No section was visible in which the dip of these igneous dykes could be made out; the impression left on the mind, however, is that they are vertical, or nearly so. In addition to these, however, are a series of acidic dykes striking in approximately the same direction as the prevailing trend of the enclosing schists. The most conspicuous of these occur in the country to the North of Bidjaronning Spring. They are of two types—viz., a very coarse variety of pegmatite and a somewhat fine-grained micaceous felsite. One of the most noticeable geological features of the area is the ferruginous conglomerate (?), which covers such an extensive tract of country in the neighbourhood. The conglomerate does not form a horizontal tableland, but, on the West, presents a steep bluff from six to eight feet in height, extending for considerable distances North and South, with scarcely any interruption. From the top of the escarpment the deposit dips gradually to the East, and seems to pass beneath the sandy soil which forms the flat country on the other side of the range. The

* H. P. Woodward. Mining Handbook to the Colony of Western Australia. 2nd Edition. Perth: By Authority, 1895; pp. 115-116.

conglomerate seems to have adapted itself to the original form of the ground upon which it was formed. Outliers of this conglomerate occur at several places on the Western fall, at elevations considerably below the general level of the range, and with a dip to the West at angles a little less than the average slope of the ground. It is quite evident that this deposit originally covered the whole of the Wongan Hills, and that extensive denudation has taken place since the conglomerate formed part of one continuous formation. In two or three localities watercourses have cut deep channels through the conglomerate, the most conspicuous being that creek which rises at about the centre of the country examined and flows gradually to the East through a narrow cañon-like channel.

Prospecting operations are at present confined to a relatively small area of the Wongan Hills; the workings are situated on the Western slope of the range, at some slight elevation above the general level of the surrounding country. So far as operations have at present been carried, the ore deposits which have been prospected consist of ordinary quartz reefs, through which various metalliferous ores are disseminated.

The reefs have a strike coincident with that of the enclosing rocks—viz., generally North and South. In several places the slopes of the hills are strewn with quartz fragments of such a character as to leave no doubt but that they had not travelled far from the position in which they had been deposited. Owing to the reefs and veins being lenticular in shape, it necessarily follows that it would only be in very exceptional cases that their outcrop would make any show on the surface. As a general rule the quartz is of a somewhat white-sugary appearance, with the exception of some of those veins at Little Wongan, which are of a limpid glassy appearance. The white-sugary variety of quartz carries hematite, limonite, azurite, malachite, and oxide of copper, together with actinolite, serpentine, and garnets. The oxides of iron are disseminated through the quartz in the form of irregular grains, as well as irregular veins traversing the quartz.

Up to the present time prospecting operations have been carried on only to a few feet from the surface, hence many details as to the structure of the reefs and other cognate points are not available.

The want of water during the greater portion of the year is a serious drawback. This, however, could no doubt be remedied by the sinking of wells in localities on the low ground at the base of the hills. It cannot, however, be said that up to the present any very promising results have been obtained by the prospecting in the district; the hope, however, may be reasonably indulged in that somewhere within the known linear extension of the Wongan Hill beds valuable discoveries may be made in the future.

Blackboy Hill.—At Cantinenti (popularly known as Black Boy Hill) situated at the head of Toodyay Brook, about 25 miles North

of the town of Newcastle, auriferous deposits have been found on private land.

The ground lies to the East of Blackboy Hill (Cantincuti), which consists of a mass of granitic gneiss. To this gneiss, on the East, succeeds a belt of about a mile in width, consisting of micaceous and quartz schist; the latter sometimes in flaggy beds. These metamorphic rocks trend generally North and South, and dip to the East at varying angles. They are intersected by diorite trending North-West and South-South-East. These beds are often concealed in part by a covering of sand and ferruginous rubble, the latter containing, in one or two localities, free gold. There are no quartz reefs, in the ordinary sense, exposed in any of the workings, but merely irregular lenticular veins of glassy quartz lying parallel to the planes of schistosity. The quartz contains, in places finely-disseminated pyrites, limonite, and, in some cases, free gold. The quartz schists are, in most cases, iron-bearing, and have been mistaken for quartz reefs of large size. The gold present is practically confined to the glassy quartz, and is present in small quantities throughout the belt of micaceous and quartz schists, and such being the case it is of course within the bounds of possibility that gold may prove to be sufficiently concentrated in any quartz reefs which may occur to be payable, but none have been discovered.

Bindoon.—A pyritous quartz reef has been worked at Bindoon, about 45 miles North-East of Perth. The rocks are stated to be slate and schist, with quartz reefs and diorite dykes, both of which have been proved to contain pyrites in fairly large quantities.

Dandalup.—Writing in 1871, with reference to Dandalup, Mr. H. Y. L. Brown remarked that the country rock consisted of a coarse porphyritic granite, intersected by dykes of different varieties of greenstone:—

> Several holes have been sunk along the creek here in searching for gold, through granite and greenstone detritus, quartz drift, etc. There are, however, no special indications which would lead anyone to expect gold here rather than in any other parts of the Darling Range.*

In 1896, prospecting was vigorously carried out in the neighbourhood, and an area was proclaimed a goldfield. Nothing, however, of a payable nature was discovered, though the district proved undoubtedly auriferous.

Brunswick River.—Prospecting operations have been carried out on private lands, situated about three miles above the Railway Station at Brunswick. The country rock consists of micaceous quartz schist or quartzite, carrying a fair proportion of pyrites. No true quartz reef had been opened up, but operations had been carried out upon beds of country rock, through which auriferous pyrites is disseminated. One of these beds of pyrites had a width of 18 feet. Appreciable quantities of gold were discovered in these

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* H. Y. Lyell Brown. Geological Report on country in the neighbourhood of Stanton Springs, Williams and Canning Rivers, Pinjarra, Bunbury, and Cape Leeuwin. Perth: By Authority, 1872.

beds; as, however, it seemed that the gold in a stone of this nature would be proportional to the amount of pyrites present, investigations were made in the official laboratory, and assays were made of the pyrites resulting from the crushing and the washing of the ore. The concentrates thus obtained assayed 19dwts. 14grs. of gold per ton; but, as the pyrites represented about four and a-half per cent. of picked stone, the actual assay value of the ore works out to be 21grs. per ton.

Greenbushes.—Gold has also been found in association with the tin ore at Greenbushes, but no details as to the mode of occurrence are available.

Kendinup.—Late in the sixties—

> Gold was found at Kendinup, on the Great Southern Railway, in a quartz reef, which contained much iron pyrites. . . . . The rocks in this neighbourhood are crystalline schists, containing many quarts reefs and diorite dykes, both carrying large quantities of iron pyrites, which contain small quantities of gold. *

Eastern Districts.—At York, and throughout the Eastern Districts, gold finds are reported from time to time, but these have never been proved to be of any value as yet; but there is not the slightest doubt that an auriferous belt extends South from the Wongan Hills by York along the Great Southern Railway to Kendinup.

The Darling Range—

> The Darling Range presents a bold escarpment to the coastal plains, and is composed of very hard crystalline and granitic rocks, striking North and South, whilst at their base, on the Western side, here and there softer rocks, such as clay, slate, and sandstone, outcrop; and wherever they are met with they contain quartz and other mineral veins, with zinc, lead, and copper ores. All along this Western face, South of Perth, there are series of immense quartz reefs, carrying large quantities of pyrites, which, on assay, prove to carry gold, but in no case rich enough to pay.†

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* H. P. Woodward. *Loc. Cit.* † H. P. Woodward. *Loc. Cit.*

CHAPTER V.

LEAD AND COPPER.

Northampton, Whim Well, Roebourne, other Localities.

Northampton.

The inception of active mining operations in Western Australia dates from the year 1842, when lead and copper mines were first discovered in this district.

> The first discovery of a copper lode was made at Wanerenooka by a man named Thomas Mason, who at that time was following the humble occupation of a shepherd in the employ of the late Mr. James Drummond.*

Mining in the early days was carried out in the most parsimonious manner, and sinking was discontinued when the lodes showed signs of contracting—a condition, however, to which all such deposits are subject. This circumstance, coupled with the low price of both lead and copper, would appear to have been the reason which led to the suspension of mining operations.

Mr. F. T. Gregory, writing in the year 1861, would seem to have been the first to describe the occurrence of the lodes of lead and copper, in the following words:—

> These lodes take an almost invariable direction of North 32° East, with a general dip of about 80° to the West-North-West, and are accompanied by parallel dykes of whinstone, quartz, or porphyry, varying from a few feet to 50 or 60 yards in breadth.†

In the year 1871 Mr. H. Y. L. Brown, then Government Geologist, examined the neighbourhood, and, in his report,‡ gave a description of such of the properties as were at that time accessible. This report, and the accompanying small scale map, is long since out of print. Mr. Brown, who had exceptional opportunities of examining the mines, wrote in no uncertain terms as to the district affording a wide field for the profitable employment of capital. The report of Mr. Brown was followed in 1888 by that of Mr. H.

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* H. P. Woodward. Mining Handbook to the Colony of Western Australia. Perth By Authority, 1895.

† On the Geology of a part of Western Australia. Q.J.G.S: London, 1861. Vol. XVII., p. 478.

‡ Geological and Mining Report on the Champion Bay Mining District, Western Australia. Perth: By Authority, 1871.

P. Woodward, from whose pen the best description§ of the mines emanated, and which has been laid under contribution:—

In this district the copper and lead ores occur associated together in the same lodes, with, sometimes, zincblende, ferruginous graphite, barytes, and quartz. The lodes, which have a course more or less North and South, make their appearance here and there, where the overlying mesozoic rocks have been removed, in a raised belt of country, about 110 miles long, stretching from the Geraldine mine, on the Murchison River, in the North, to the Irwin River, in the South. They consist of very large and rich deposits of lead and copper, which were successfully worked for many years. . . . The lead is found in the form of carbonate (Cerrusite) and sulphide (Galena) of great purity, and the lodes, which are of immense width, contain so little gangue mixed with the ore that the galena can be dressed, with very little labour, up to 83 or 84 per cent. . . . . . The copper ores are also very rich, consisting, near the surface, of the blue and green carbonates (Azurite and Malachite) with ferruginous oxides and a certain amount of native copper; whilst below the water level the lodes are almost entirely composed of sulphides (Copper Pyrites, Copper Glance, and Covellite). . . . . .

During a preliminary examination of the district in the early part of 1897, the association of the lodes with certain basic dykes, which traverse the country for considerable distances with a remarkably persistent trend, was forcibly apparent. These dykes being of commercial importance, owing to their intimate connection with the deposition of metalliferous minerals, it seemed that the greatest assistance the Geological Survey could render to private enterprise in such a district would be in the direction of accurately mapping these igneous rocks, and by so doing afford a reliable guide as to the horizontal extent of the ore bodies, and, possibly, lead to the discovery of others.

The district occupies an elevated tract of country drained by the tributaries of the Bowes River, which all take their rise in the rugged hills forming the most Northerly portion.

From beneath a series of sandstones and conglomerates emerge the crystalline rocks which form the matrices of the copper and lead lodes. These beds, which consist of granite, gneiss, mica schists, quartz schists, etc., are intersected by veins and masses of pegmatite. It was found almost impossible to draw any line separating each of these rocks, hence all have been delineated by the same distinctive marking on the attached plan. (Plate iii.)

The summit of a bare hill East of Brookside Farm, just above the junction of the Udandarra Creek with Nokenena Brook exposes a sheeted zone of micaceous and garnetiferous schist. The rock is traversed by a band of quartz, often much contorted and puckered, and stands out in such bold relief as to be readily followed by the eye across country. The general trend of these sheeted zones is North-West and South-East. Another similar parallel sheeted zone of garnetiferous gneiss occupies the country to the South-East of the Baddera Mine, at the head of the Udandarra Creek, and an identical band makes its appearance to the South-East of Reserve 1374, at the foot of the sandstone tableland at the head waters of the Bowes River. What appears to be a continuation of this band

§ H. P. Woodward, *Loc. Cit.*

is visible in the vicinity of Poison Well. It does not appear that these sheeted zones have been impregnated with metalliferous minerals. A remarkably persistent band of quartz schist can be traced from Two-Mile Hill to the South of the country examined. The schist, which presents a bold topographical feature, forms a horseshoe-shaped curve, passing through the Two-Mile Hill and Trig. Station, No. 18, and for some considerable distance further; occupying, in all, a distance of about three miles. The quartz schist has a steep dip to the East.

The most important structural feature is the system of basic dykes with which the whole area is seamed. These dykes have no apparent connection with any visible deep-seated rock of similar composition. The basic dykes exhibit, when their trend is laid down upon a map (Plate iii.) with some degree of accuracy, a remarkable parallelism, having a general trend of North-East and South-West, or, approximately, at right angles to the sheeted zones above mentioned. The longest has been traced across country without interruption for a distance of over 10 miles, and extends both North and South far beyond the limits of the country examined. The breadth varies much in different places, but in no case was the width exposed on the surface very great. Wherever any sections were visible the dykes were either vertical or inclined at very high angles. The rocks of which the dykes are composed are all basic compounds, and have a specific gravity of 3·07.

Over the whole of the Northampton District there is not a mine which has been sunk to any great depth, and operations ceased when the lodes showed signs of cutting out. The lodes of lead and copper, which have already been opened up, are parallel to the basic dykes. Igneous dykes of this nature represent what were originally fractures in the earth's crust, which pass downwards to very considerable depths, and the lodes fill in fissures of a similar character which find their origin far below the limit of practical mining. The lodes, in consequence, will continue downwards as far as ever operations are likely to be carried. The method of the formation of fractures and the movement of either of the walls have the effect of producing alterations in the nature of the fissures by forming wide or narrow portions, which have been subsequently filled with ore. There must always be local variations in the metallic contents of ore bodies, but there are no scientific grounds for believing that the mines of this district have reached the limits of ore deposition, and that the ore bodies will not prove equally productive when followed either horizontally or vertically. As the deposition of ore bodies is most intimately connected with the system of fracturing to which the district has been subject, it is evident that the search for further lodes must follow that direction which the evidence already accumulated has shown to be that of greatest ore deposition; and this direction is that which lies parallel to the system of basic dykes. Judicious prospecting carried out upon these lines should result in the discovery of other lodes equally productive to those already exploited.

Mining appears first to have commenced in the year 1842, and, since that date up to the end of 1899, 12,677 tons of copper ore, valued at £208,298, and 33,617 tons of lead ore, valued at £364,514, have been exported from the Colony. Of this quantity 43,407 tons may be credited to the Northampton District.

Appended will be found several tables showing the quantity of copper and lead ore exported from the Colony since 1850. The first shipment of ore from the district is said to have taken place during the year 1845; but no details as to either the quantity or the value are available. These tables do not show the actual quantity of metallic lead and copper produced from the ore. It is, however, desirable that, in future statistics, this information should be supplied.

Whim Well.

The Pilbarra District seems to be very rich in ores of copper, the most important locality being at Whim Creek. The district has been visited and reported upon some years ago by Mr. H. P. Woodward, who states that:—

> The mine is situated upon the North-West Coast, about 50 miles to the Eastward of Roebourne, near Mount Negri, and when it is stated that it was worked by about four men for a month or two in 1890, and that, from the results, the syndicate were able to pay all the working and preliminary expenses, some idea can be gained of the richness, size, and quality of the lode. . . . The lode is on the surface, forming the face of a low ridge running East and West for about half-a-mile, when it is lost at both ends. It dips gently to the North at an angle that allows it to be worked comfortably on the footwall, *i.e.*, with just sufficient pitch to allow masses to be rolled down, and yet not too steep for men to work upon it. It is 12 feet in thickness where it has been opened, 6 feet of which can be dressed without the slightest trouble to 30 per cent., and with care even to 40 per cent., whilst the other 6 feet can be dressed to 20 per cent. with a little trouble, and if a proper dressing plant were erected better results could be obtained. The lode appears to be good in quality throughout its entire length, and is nowhere, as far as can be judged from the surface, less than 6 feet in thickness, and most of it is a good deal more. The ore consists of the liver-coloured mixture of oxides and carbonate, chiefly green, but there is some blue also in the poorer parts of the lode, while, in the rich, some beautiful specimens of malachite have been obtained, and some large slugs of native copper.

Roebourne.

> Some copper workings were opened a few years ago a little South of Roebourne. They are situated at a base of some low slate and quartzite hills on the edge of a large flat formed by one of the branches of the Harding River. These lodes are chiefly oxides of iron and copper, in some of which gold is visible. There are two sets of lodes, one running more or less North and South and dipping East, while the other runs East and West and dips North. . . . . Large ferruginous copper lodes occur all over this district, some of which carry from 30 to 40 per cent. of copper ore, but the mass of the lode stuff is iron. In some of the specimens gold is plainly visible. . . . .

The following table shows the production of copper ore from the North-West so far as can be judged by the records of the Customs House:—

Production of Copper Ore from the Pilbarra District.

Year.	Ore Exported.			Value of Ore.		
	tons	cwt.	qrs.	£	s.	d.
1891	262	0	0	(not available)		
1892	412	0	0	do.		
1893	50	0	0	606	0	0
1894	*Nil*			...		
1895	802	0	0	12,832	0	0
1896	6	6	0	100	0	0
1897	64	17	0	731	5	0
1898	280	17	0	3,335	0	0
1899	1.404	0	2	31,979	0	0
Total ...	**3,282**	**0**	**2**	**48,983**	**5**	**0**

Other Localities.

In the Kimberley District some very fine copper ores exist. They are associated with small quantities of gold. The geographical position of the deposits is, however, at present, a bar to their successful working.

Lodes of lead and copper are also known to occur in the country between Arrino Springs and the Irwin River, in the Yandanooka mining district. No details in connection with these, however, are available.

Copper also occurs in the Wongan Hills, disseminated in varying quantities through ordinary quartz reefs. The reefs have a strike coincident with that of the enclosing schists, viz., North and South. As a general rule the quartz is of a somewhat white sugary appearance, which carries hematite, limonite, azurite, malachite, and oxide of copper, together with actinolite, serpentine, and garnets. The oxides of iron are disseminated through the quartz in the form of grains as well as irregular veins traversing the quartz. Assays have been made in the official laboratory of different portions of the quartz reefs, with the result that gold to the extent of 1dwt. per ton was obtained, and copper from 8 to 16 per cent.

Copper ores are also known near Middle Mount Barren, on the South Coast, in the Phillips River mining district; but as no geological examination has been made of the district, details as to their mode of occurrence and other cognate points are not available.

The following tables give the production of the ores of lead and copper of the Colony as well as that of pig lead, as shown by the archives of the Collector of Customs:—

The Production of Copper Ore in Western Australia.

Year.	Ore Exported.	Value of Ore.	Year.	Ore Exported.	Value of Ore.
	tons cwt. qrs.	£ s. d.		tons cwt. qrs.	£ s. d.
1855	2 0 0	26 0 0	1878	9 0 0	135 0 0
1856	57 0 0	1,018 0 0	1879	...	...
1857	80 0 0	1,920 0 0	1880	8 0 0	120 0 0
1858	433 0 0	9,531 0 0	1881	...	...
1859	941 0 0	14,122 0 0	1882	1 10 0	22 0 0
1860	517 0 0	8,021 0 0	1883	5 0 0	75 0 0
1861	409 0 0	6,339 0 0	1884	118 0 0	1,770 0 0
1862	783 0 0	12,536 0 0	1885	119 10 0	1,792 0 0
1863	760 0 0	12,208 0 0	1886	249 0 0	3,735 0 0
1864	1,076 0 0	17,216 0 0	1887	23 0 0	345 0 0
1865	886 0 0	13,290 0 0	1888	87 10 0	1,487 10 0
1866	337 0 0	5,055 0 0	1889	112 0 0	1,904 0 0
1867	557 0 0	8,362 0 0	1890	8 0 0	136 0 0
1868	83 0 0	1,245 0 0	1891	262 0 0	4,463 10 0
1869	155 0 0	2,325 0 0	1892	567 0 0	8,696 0 0
1870	6 0 0	90 0 0	1893	50 0 0	606 0 0
1871 to 1872	*Nil*	...	1894	No data	
			1895	826 0 0	12,952 0 0
			1896	6 6 0	100 0 0
1873	56 10 0	847 0 0	1897	86 0 0	1,033 0 0
1874	66 10 0	998 0 0	1898	355 8 0	4,266 0 0
1875	255 0 0	3,071 0 0	1899	1,991 5 0	41,452 0 0
1876	279 0 0	4,185 0 0			
1877	53 10 0	802 0 0			
			Total	**12,677 9 0**	**208,297 10 0**

The Production of Lead Ore in Western Australia.

Year.	Ore Exported.	Value of Ore.	Year.	Ore Exported.	Value of Ore.
	tons cwt. qrs.	£ s. d.		tons cwt. qrs.	£ s. d.
1850	5 0 0	55 0 0	1875	2,289 0 0	27,468 0 0
1851 to 1852	*Nil*	...	1876	2,191 10 0	26,298 0 0
			1877	3,955 10 0	47,466 0 0
			1878	3,617 10 0	43,410 0 0
1853	*a*	4 0 0	1879	2,775 0 0	33,300 0 0
1854	*Nil*	...	1880	1,921 0 0	15,368 0 0
1855	25 0 0	250 0 0	1881	1,400 10 0	11,204 0 0
1856 to 1858	*Nil*	...	1882	1,793 10 0	14,348 0 0
			1883	1,038 0 0	7,266 0 0
			1884	696 0 0	4,872 0 0
1859	13 10 0	135 0 0	1885	465 0 0	3,255 0 0
1860	98 10 0	985 0 0	1886	611 0 0	4,277 0 0
1861	79 0 0	790 0 0	1887	471 0 0	4,710 0 0
1862	9 0 0	90 0 0	1888	532 0 0	5,320 0 0
1863	230 0 0	2,300 0 0	1889	250 0 0	2,500 0 0
1864	80 0 0	800 0 0	1890	213 10 0	2,135 0 0
1865	703 0 0	8,436 0 0	1891	25 0 0	250 0 0
1866	273 10 0	3,282 0 0	1892	29 15 0	150 0 0
1867	902 0 0	10,824 0 0	1893 to 1896	*Nil*	...
1868	1,100 10 0	13,206 0 0			
1869	699 10 0	8,394 0 0			
1870	1,209 10 0	14,514 0 0	1897	*a*	4 0 0
1871	420 0 0	5,040 0 0	1898	5 0 0	33 0 0
1872	364 0 0	4,368 0 0	1899	16 0 0	96 0 0
1873	965 10 0	11,586 0 0			
1874	2,143 15 0	25,725 0 0	Total	**33,617 0 0**	**364,514 0 0**

a No tonnage given. Declared at £4.

Export of Pig Lead from Western Australia.

Year.	Pig Lead Exported. tons	cwt.	qrs.	Value of Pig Lead. £	s.	d.
1853	55	0	0	1,200	0	0
1854	122	0	0	2,440	0	0
1855	133	15	0	2,675	0	0
1856	60	0	0	1,200	0	0
1857	120	10	0	2,410	0	0
1858	61	0	0	1,220	0	0
1859	24	15	0	495	0	0
1860 to 1866	No data			...		
1867	*a* 3	0	0	50	0	0
1868 to 1874	No data			...		
1875	4	5	0	89	5	0
1876	*a* 7	0	0	155	0	0
1877	*a* 1	0	0	15	0	0
1878 to 1879	No data			...		
1880	*a* 5	0	0	89	0	0
1881	*a* 1	0	0	20	0	0
1882 to 1886	No data			...		
1887	*a* 6	0	0	120	0	0
1888	*a* 2	0	0	40	0	0
1889 to 1896	No data			...		
1897	*b* 0	10	0	11	0	0
1898	No data			...		
1899	77	0	0	1,077	0	0
Total ...	**683**	**15**	**0**	**13,306**	**5**	**0**

a No tonnage given. Estimated.
b No tonnage given. Six packages estimated at 10 cwts.

CHAPTER VI.

TIN.

General.—Greenbushes, Pilbarra, and Kimberley.

Tin has been discovered in three widely-separated localities in the Colony, viz., at the heads of the Bow and the Lennard Rivers, in the Kimberley District; at Brockman's Soak and the Western Shaw, in the Pilbarra District; and at Greenbushes, in the South-Western portion of the Colony. Mining operations have been most active at Greenbushes; a little has been done at Pilbarra but, so far as official information goes, no prospecting seems to have been carried out

Greenbushes.—The discovery of tin at Greenbushes would seem to have been due to the researches of the late Mr. E. T. Hardman, a former Government Geologist. This gentleman, while engaged upon official duties in the Blackwood District, was accompanied by

a Mr. Stinton, to whom Mr. Hardman suggested the probable occurrence of tin-bearing deposits. Having this in mind, Mr. Stinton, at the conclusion of the journey, returned to Greenbushes, and after a time eventually discovered the rich stream deposits worked by a Bunbury syndicate.

The Greenbushes Tinfield, as defined by the authorities, is situated on the comparatively lofty tableland drained by the heads of Norilup and Hester's Brook. The highest point of this tableland is 900ft. above sea level, and is crossed by the main road from Bridgetown to Donnybrook.

The surface of this tableland is hilly and broken, but to the South-Westward the creeks open out into large swampy flats, which are drained by steep rocky channels into the Blackwood River. The field is connected with the main railway system of the Colony.

The salient geological features have been described by Mr. H. P. Woodward in 1891, who wrote that "the formation of the district consisted for the most part of crystalline rocks (of the age of which the district affords no clue), alluvial deposits, and the ferruginous conglomerate, which covers by far the larger portion of the tinfield." The crystalline rocks consist chiefly of gneissose and granitic rocks, intersected by dykes of diorite, tourmaline granite, and schorl-rock. All the rocks have a general North and South strike. The area which these rocks occupy on the surface can be seen on the small scale-map herewith.

The tin deposits of Greenbushes fall naturally into two distinct categories:—

Superficial Deposits:

(*a.*) Alluvial deposits.
(*b.*) Residuary sands, gravels, etc.

Deposits in Country Rock:

(*c.*) Tin-bearing granite.
(*d.*) Tin-bearing dykes.

(*a.*) *Alluvial Deposits.*—These are found flanking the course of all the existing watercourses; their extent has been accurately delineated upon the geological map Plate II., from which it can be readily seen that they do not cover a relatively large area. The alluviums do not attain any very great thickness, but a fairly large proportion of tin has been derived from these deposits. The whole of these modern alluviums are not tin-bearing; the richest seems to be that formed by Spring Gully and its tributaries. A great deal of work has been accomplished in Spring Gully, and more especially on the tributaries entering it on the North. The deposit in Spring Gully consists of two distinct portions:—

(1.) An upper, or "free dirt," *i.e.*, loose gravel; and
(2.) A lower, stiff, "clayey dirt," containing irregular bands of detrital tin.

The free dirt, which varied from one to three feet in thickness and about 18 to 20 yards in width, proved exceptionally rich in tin. The physical character of some of the tin shows that it can only

have been released from the parent rock in close proximity to where it is at present found. No small portion of it has been derived from the denudation of the granite belt, reticulated with tin-bearing veins, which crosses Spring Gully from North to South.

An older alluvium is exposed in what is known as Elliot's Gully, a tributary of the Bunbury, and has been extensively worked at different times. The "wash" lies at 50 feet from the surface. The wash is a very coarse conglomerate, with a very large proportion of flat-sided boulders, cemented together in part with oxide of iron. The conglomerate or cement, which has an average thickness of about two feet, shows tin freely. Directly overlying the cemented wash is a fairly extensive deposit of white, gritty sand, which contains a relatively large proportion of detrital tourmaline. The floor upon which the deposit rests consists of vertical decomposed clay-slates, which strike South-East and North-West.

(*b.*) *Residuary Sands, Gravels, etc.*—In addition to the alluvial deposits, by far the larger portion of the field is covered with a mantle of very variable thickness of sands, gravel, and conglomerate. These deposits are not of an alluvial character, but owe their origin to the decomposition *in situ* of the underlying rocks. The sands unite in giving what is practically a uniform section, which consists of from two to three feet of peaty soil, succeeded by a very variable thickness of white, gritty sand, carrying varying proportions of mica, tourmaline, and occasionally tin. These sands result from the residual decomposition of a granitic rock, which may or may not be reticulated with tin-bearing veins.

One of the most noticeable features in the structural geology of Greenbushes is the ferruginous conglomerate and gravel, the position of which has been accurately delineated upon the geological map attached. In its mode of occurrence the conglomerate presents one important feature, viz., that it does not form a horizontal table-land, but occurs at different elevations, and seems to have adapted itself to the original contour of the ground upon which it originated. The conglomerate covered a much larger area than it at present occupies, and denudation has gone on to a large extent since it formed part of one continuous formation. The thickness of the conglomerate is nowhere very great, operations having shown that it rarely, if ever, exceeds 20 feet. The conglomerate is not of sedimentary origin, but has apparently been formed by the alteration *in situ*, and subsequent cementation of the underlying rocks. In some portions of the field this conglomerate (as is only to be expected from its mode of origin) carries a certain quantity of tin. The ore, however, is not evenly distributed throughout, but seems to be concentrated in certain comparatively isolated patches. The tin from this conglomerate cannot be extracted by the ordinary process of washing without milling. Like alluvial deposits, these residuary gravels and conglomerates are evanescent, and can be exhausted.

Both the modern alluviums and the residuary sands, gravels, and conglomerates have yielded by far the greater portion of the

tin turned out from Greenbushes. It by no means follows that the richness of these is proof of exceptionally rich lodes or veins beneath; for, owing to the extreme difficulty with which certain minerals are acted upon by atmospheric agencies, they often remain to gradually accumulate in much greater quantity than existed in the parent rock. It is to this natural process of concentration that the richness of the superficial accumulations of Greenbushes is due.

(c.) Tin-bearing Granite.—The tin-bearing granite consists of a granite passing in places into a foliated and highly-micaceous granite, with little or no felspar. This granite (greisen) contains tin, tourmaline, zircon, garnet, etc., as accessory constituents. In some parts of the field the tourmaline occurs in such quantity in the gneiss as to give a distinctive character to the rock, and would be better described as a tourmaline gneiss. Some specimens of this highly micaceous rock from Caporn's Deep Shaft, now known as the Cornwall, yielded on assay in the official laboratory tin to the extent of 1·79 parts per hundred. A "tin floor" has been worked at the head of Spring Gully on an old lease (82 244), at a depth of 16 feet from the surface. The floor, a tin vein, was found underlying at a low angle to the North-West. The vein had been followed for about 40 feet to the rise, *i.e.*, South-East. The tin, which is associated with tourmaline, quartz, and a little mica, is confined to a zone of about one foot in thickness. The country rock is a decomposing granite. On the Southern bank of Bunbury Gully, not far from its head, another well-marked "tin floor" has been worked at a depth of about 30 feet from the surface. The "floor" underlies at a low angle to the West. The material forming the floor, locally spoken of as "wash," is about 2 feet 6 inches in thickness, and consists of mica, quartz, a little tourmaline and tin. The deposit occurs within the zone of decomposition of the tin-bearing granite.

The tin-bearing granite occupies a definite and fairly well-defined belt, trending approximately North-West and South-East from Hester's Troughs, Bunbury Gully, across the heads of Dumpling Gully, and a little to the East of Horan's claim; it includes Bishop Gibney's ground, the heads of Spring Gully and Cowan Brook. This direction coincides with that along which lines of weakness have been produced by earth movements of considerable intensity; it is along these fractures that mineral-bearing solutions have penetrated and deposited the tin. This granite has been reticulated by a number of tin-bearing veins, forming a stock-work, and many have already been worked in the zone of surface decomposition as alluvial deposits. This area is not, however, coterminous with the legal boundaries of the field; the continuation of the tin-bearing belt should be looked for in both a North and South direction. The presence of the ubiquitous conglomerate, however, would render prospecting on the North most difficult. The best localities to search for further deposits would be along lines of greatest erosion, and that is in the vicinity of the present water-courses.

(d.) Tin-bearing Dykes.—These occur in several parts of the field. One of the most typical occurs on the Eastern side of the main Bridgetown Road, upon what was originally M.L. 82/76. A shaft had been put down to a shallow depth upon a tourmaline-bearing dyke, which was met with beneath the conglomerate at a depth of about 5 feet below the surface. The conglomerate contains detrital tourmaline, which led to the discovery of the dyke. As exposed in the workings, the width of the dyke is about 2 feet 6 inches, having a general North-Westerly strike, with an underlie to the South-West at an angle of 70°. The tourmaline is enclosed in a ferruginous clayey matrix, which contains occasional patches of quartzose material; the dyke may be a tourmaline-bearing pegmatite. The rock contains a small quantity of very angular tin, associated with large quantities of titanium. The tourmaline itself carries in parts appreciable quantities of tin. An assay of a carefully-selected sample, believed to be characteristic of the whole dyke, yielded in the official laboratory 1·97 parts per hundred of metallic tin. There are several other parallel dykes throughout the field, but, so far, they have not been very much exploited, and do not appear to be very rich.

Whatever doubt there may have been as to the occurrence of ore deposits, other than superficial accumulations, has been definitely set at rest. The ore bodies are not lodes within the strict meaning of the term, but are merely a network of irregular tin-bearing veins, distributed over a fairly well-defined area. Such deposits, which owe their origin to deep-seated sources, are as likely to be as permanent as anything in the nature of such ever can be. It, however, by no means follows from this that any individual vein can be followed laterally or vertically for any great distance, but each vein will give place to another, and so on.

Owing to the extremely low assay values of many consignments of what seemed to be perfectly clean tin ore, which has been shipped from the district, attention has been naturally directed to the mineralogical characteristics of the ore. It was found that associated with the tin was a mineral of about the same specific gravity as cassiterite, rendering it almost impossible to separate the two mechanically. These investigations confirmed those made by Mr. G. A. Goyder, the Government Analyst of South Australia, in 1893, whose analysis showed the foreign mineral to be essentially a tantalate of antimony, of the following composition:—

Tantalic Oxide, Ta_2O_5	51·13
Niobic Oxide, Nb_2O_5	7·56
Antimony Trioxide, Sb_2O_3	40·23
Bismuth Trioxide, Bi_2O_3	·82
Nickel Protoxide, NiO	·08
	99·82
Specific gravity	7·37

A complete analysis of marketable ore assaying low in tin was made in the Departmental Laboratory, with the following result:—

Loss on ignition	·22
Tin Dioxide, $Sn\ O_2$	53·14
Titanic Oxide, $Ti\ O_2$	·67
Silica, $Si\ O_2$	1·61
Ferric Oxide $Fe_2\ O_3$	4·11
Alumina, $Al_2\ O_3$	·42
Manganese Protoxide, $Mn\ O$	1·61
Lime, $Ca\ O$	·69
Magnesia, $Mg\ O$	·39
Antimony Trioxide, $Sb_2\ O_3$	15·13
Bismuth Trioxide, $Bi_2\ O_3$	Trace
Tantalic Oxide, $Ta_2\ O_5$	19·85
Niobic Oxide, $Nb_2\ O_5$	3·56
	101·40
Metallic Tin	41·80

Owing to the fact that Antimony Oxide tends to form an extremely impure tin alloy, a considerable loss of tin might result in refining. Doubtless this drawback can be overcome when the properties of the mineral (stibio-tantalite) have been properly investigated. The occurrence of this mineral may be held to explain why some of the returns to the vendors of tin ore have fluctuated so considerably.

Since the year 1891, mining has been carried out in somewhat desultory fashion, and, considering all things, a fair quantity of tin has been raised, as disclosed by the records kept in H.M. Customs House. These figures until quite recently were the only data available for arriving at the yield of the Greenbushes Tinfield, which is shown in the following table:—

Export of Tin Ore from the Greenbushes Tinfield.

Year.	Ore exported. tons	cwts.	qrs.	Estimated Value. £	s.	d.	Remarks.
1891	204	0	0	10,300	0	0	The Mining Registrar at Greenbushes reports:—"Of previous years there is no record either at Bunbury or Fremantle, and I believe the amount to be inconsiderable."
1892	265	9	3	13,843	0	0	
1893	171	10	0	7,664	0	0	
1894	371	5	0	14,325	0	0	
1895	277	3	0	9,703	0	0	
1896	137	5	0	4,338	0	0	
1897	95	11	0	3,275	0	0	
1898	68	2	3	2,760	0	0	
1899	278	8	1	21,138	0	0	
Total	1,868	14	3	87,346	0	0	

Pilbarra.—"Tin has also been found in the alluvial workings at Pilbarra . . . . A very rich deposit of coarse stream tin occurs near Messrs. G. & J. Withnell's station on the Shaw, which assayed 71 per cent. of metallic tin . . . ."*

No geological examination of the district having been made, no further information is available.

Tin has also been worked in 1899 on the Coongan River, about 10 miles South of Marble Bar. The country is said to be very favourable for the occurrence of tin deposits.

The following table gives the yield of the Pilbarra District, so far as can be judged by the Customs records:—

Export of Tin Ore from Pilbarra.

Year.	Ore exported.			Estimated Value.			Remarks.
	Tons	cwt.	qrs.	£	s.	d.	
1893	56	9	0	3,470	0	0	
1894	19	0	0	949	0	0	
1895 } 1898 }	0	0	0	0	0	0	
1899	29	11	0	2,025	0	0	
Total	**105**	**0**	**0**	**6,444**	**0**	**0**	

KIMBERLEY.

Oxide of Tin is known to occur in the gravels at the heads of the Bow and the Lennard Rivers, but no details are available.

The table below gives the export of tin ore from the Colony.

The Production of Tin in Western Australia.

Year.	Tin Ore exported.			Estimated Value.			Remarks.
	tons	cwt.	qrs.	£	s.	d.	
1889	5	0	0†	300	0	0	† The Collector of Customs reports:—"In all probability the produce of the Greenbushes Tinfield."
1890	67	10	0†	5,400	0	0	
1891	204	0	0	10,300	0	0	
1892	265	9	3	13,843	0	0	
1893	227	19	0	11,134	0	0	
1894	390	5	0	15,274	0	0	
1895	277	3	0	9,703	0	0	
1896	137	5	0	4,338	0	0	
1897	95	11	0	3,275	0	0	
1898	68	2	3	2,760	0	0	
1899	307	19	1	23,163	0	0	
Total	**2,046**	**4**	**3**	**99,490**	**0**	**0**	

* H. P. Woodward. *Loc. Cit.*

CHAPTER VII.

IRON ORES.

General.—Analyses of Western Australian Iron Ores—Kimberley, Horseshoe Range, Weld Range, Mount Narryer Range, Mount Taylor, Mount Hale, Mount Gould, Coolgardie, Coates' Siding and Mount Baker, Greenbushes, Wongan Hills. Meteoric Irons—Production of Iron Ore.

The ores of iron are extremely widely distributed throughout Western Australia, yet, with one or two exceptions, the area in which the exploitation of such deposits is actively prosecuted is very limited; a condition of affairs for which the distance from market, and the comparatively low price at which iron can be landed in the Colony, may be held accountable. Some of the richest and most extensive iron deposits are absolutely valueless, owing to their geographical position; a condition of affairs which increased facilities for transport might rectify.

The iron deposits of the Colony, so far as our present knowledge is concerned, can be broadly separated into two main divisions—a grouping which is based in part upon their chemical composition, and in part upon their mode of occurrence:—

(*a*.) The ores associated with the crystalline schists and other allied rocks; and

(*b*.) The superficial deposits of limonite which occupy such extensive areas in many parts of the Colony, and for which the Indian term Laterite Ore, or the Roche à Ravets of French Guiana (with which the deposits are comparable) would be appropriate.

The following table shows the results of the analyses of certain of the iron ores of the Colony, as made in the Departmental Laboratory :—

Table of Analyses of Western Australian Iron Ores.

Nature of Ore.	Locality.	Analysis.	
		Metallic Iron per cent.	Other Determinations.
Concretionary Ironstone (Laterite)	Mt. Baker ...	51·33	Manganese monoxide, trace ; silica, 4·44°/ₒ.
Do.	Do. ...	50·54	Manganese monoxide, trace ; silica, 5·49°/ₒ.
Do.	Darling Range	34·73	Manganese monoxide, *nil* ; silica, 19·44°/ₒ.
Do.	Do. ...	45·00	Manganese monoxide, trace ; silica, 9·88°/ₒ.
Do.	Do. ...	41·60	Manganese monoxide, trace ; silica, 11·33°/ₒ.
Do.	Do. ...	59·63	Manganese Monoxide, 0·35°/ₒ ; silica, 1·59°/ₒ.
Do.	Do. ...	66·96	Silica, 2·21°/ₒ.
Magnetite	Collie District	64·48	
Turgite (Laterite) ...	Greenbushes ...	62·47	
Argillaceous Ironstone (Lodestuff)	Wiluna ...	35·5	
Hematite	4 miles N.-W. of Munara Gully, Murchison G.F.	63·7	
Do.	Bardoc (G.M.L. 2534)	55·5	
Concretionary Ironstone (Laterite)	Menzies ...	28·2	
Limonite	Mt. Jackson ...	53·0	
Siliceous Hematite ...	Mt. Narryer ...	56·7	
Hematite	Mt. Hale ...	65·8	
Clay Ironstone (Laterite)	Coolgardie (G.M.L. 2843)	25·13	

Kimberley.—The sandstones of the Upper Carboniferous Series of Kimberley abound in nodular and spheroidal masses of hematite. Spheroids fully 6ft. in diameter have been noticed at Duke's Dome, to the South of the Fitzroy River. "Some of these nodules, whether of the size just mentioned, or only a few inches in diameter, consist of a nucleus of sandstone coated with a more or less pure hematite. Sometimes the sandy interstice is quite soft, and then on breaking the specimens this falls out, and the result is a hollow shell. But more often the iron deposit adheres closely to a firm nucleus of grit. The ironstones are often a black carbon colour, due to the presence of magnetic iron sand. When the rock is powdered, this can easily be extracted by means of a magnet. Commercially these iron ores are of no value, as in general the amount of metallic iron is low, and even if

they were of the best quality they would hardly pay for the labour of extracting them from the rock." * Thick veins of iron ore have been noticed in the limestones of the Rough Range, and in the sandstones to the East of the Mount Elder Range.

"The quantity of iron disseminated throughout the various rock formations of Kimberley is something enormous, and the deposits often assume most fantastic forms; thus, to the South of the Grant Ranges, near the Fitzroy River, there are low hills of carboniferous sandstone; on the surface of which rock, and on the lower ground are strewn quantities of large pieces of rusty ironstone, exhibiting a great variety of artificial looking structure. Some of these specimens show on the surface most intricately folded and twisted patterns, while others resemble the metal framework of a lattice church window." †

Horseshoe Range.—The Horseshoe Range, which is virtually a combination of that low line of hills extending from the township of Peak Hill, is composed of hematite-bearing quartzites, of the type described below, which dip at a high angle to the West. The outcrop of the iron-bearing series forms the most conspicuous feature in the range, and is visible for great distances. These beds are of interest, in that some of them have proved to be highly auriferous.

Weld Range.—In the Weld Range, at the head of the Roderick River, is the celebrated Wilgie Myah, said to be probably one of the richest iron lodes in the world. The deposit consists "almost entirely of hematite, which, at the surface, and in the cavities, assumes the botryoidal form, which has given rise to the idea that it is a lava flood. It is situated on the East side of the Weld Range, and runs East and West dipping North, following the main strike of the rock. In these lodes there are soft bands, often clayey. These the kangaroos scratch out, forming caves, and it is probably in this way that the natives first made the discovery that this lode could be easily worked by following these beds. It has now been opened up as a huge pit or quarry, to a depth of about 100 feet. This is entered near the top of a hill (about 70 or 80 feet above the plain) by a hole about 50 feet across; then a steep descent commences over the talus in a South-Easterly direction. At the bottom it spreads out to about 50 yards wide, with the roof some 50 feet above, and numerous cave-like galleries running into the face in all directions. "The Wilgie is worked by cutting round a mass of it, then wedging it off. This work, though very primitive, is very interesting, as the natives work with their wooden tools much in the same way that the ancient miners did in Great Britain with stone hammers. There are also rude attempts at staging, to allow the miners to work up into the roof, when veins of sufficiently good quality run that way. "In contemplating this pit one is struck by

* The Geology of the Kimberley District, Western Australia: E. T. Hardman, Perth; By Authority: 1884; p. 9.

† On the Geology of the Kimberley District, Western Australia; E. T. Hardman, Perth; By Authority: 1885; pp. 33-34.

the vastness of the work, and when we consider the small quantity of Wilgie that can be required, it must have been worked for centuries. Of course it was worked on a much larger scale before the white invasion of Western Australia, and was probably traded great distances. As far as the lode itself is concerned it is most magnificent iron ore, and considering its size will, without doubt, be of great value in the future."*

Mount Narryer Range.—The outcrop of a bed of ironstone forms a conspicuous feature on the surface at the foot of the Mount Narryer Range. The bed is vertical; it trends North-North-East, attains a thickness of eight or nine feet, and rises about two feet above the ground. Similar beds of ironstone occur in other portions of the range; they are interbedded with and can sometimes be seen replacing quartz schists. An assay of one of these hematite-bearing schists (338) from Mount Narryer, in the Survey laboratory, yielded 81·03 per cent. of ferric oxide.

Mount Taylor.—That sigmoid-shaped range of hills on the West of the Murchison River, of which Mounts Taylor, Hale, Matthew, Yarrameedie, and Erawandoo form the most prominent summits, is particularly prolific in iron-bearing schists. Just under the summit of Mount Hale, the quartzite is replaced by an enormous bed of hematite, several huge monoliths of which stand out prominently on the range. The trend of this hematite can be followed by the eye along the range just to the South of the summit of Mount Matthew. An assay of a sample of this bed yielded the following composition:—

Ferric Oxide, Fe_2O_3	... ...	94·05%
Ferrous Oxide, FeO	... ...	0·97%

Mount Hale.—The summit of Mount Hale is formed of contorted quartzites or quartz schists, with bands of hematite, which occur in lenticular masses; some bands are often as thin as a sheet of paper, whilst others gradually widen out to enormous dimensions. One band measured 70 feet across, and outcropped for over a quarter of a mile, but varied in thickness in different parts. There were similar bands to it, and equally persistent along the strike.

Mount Gould.—The *massif* of Mount Gould lies to the North of Mount Matthew. Its flanks and summit are composed of iron-bearing schists. One conspicuous band forms the summit of Mount Gould. The hematite occurs in what may be aptly described as a modified laccolite form.

Coolgardie.—In the course of the Geological Survey of Coolgardie it has been found † that semi-detached patches of ironstone gravel, trending generally North and South, lie at a somewhat uniform level between 1,380 and 1,460 feet above sea level. The dissemination of the ferruginous matter derived from these ironstone beds is accountable for the red colour of the alluvium and other

* The Murchison Goldfield. H. P. Woodward, Perth; By Authority: 1893; pp. 20, 21.

† The Geology of the Coolgardie Goldfield. Torrington Blatchford. Bulletin No. 3, Perth; By Authority: 1899; pp. 35-36.

superficial accumulations by which the deposits are surrounded. These ironstone gravel beds vary from a few inches up to 15 feet in thickness. The ferruginous clays have been altered *in situ* into ironstone nodules, which pass upwards into hard ironstone pebbles, these latter have in places been cemented together, forming compact pure ironstone. An analysis of a fairly typical sample, from near Retribution Gold Mining Lease 2483, yielded, in the official laboratory, the following percentage composition:—Ferric Oxide 32·25, Ferrous Oxide 00·51, which is equivalent to 25·07 per cent. of metallic iron. It is interesting to note that some of these gravels yielded on assay from 3 to 8dwts. of gold per ton.

Coates' Siding and Mount Baker.—In these localities, which are about 40 miles from Perth, there is a very large area of a ferruginous conglomerate, which analyses have shown to contain an average of about 12 per cent. of iron. The surface of the ground occupied by the conglomerate is generally covered with a glazed crust of limonite (hydrated oxide of iron) of a reddish-brown hue. A freshly broken surface shows the rock to be mottled with different shades of brown or yellow, and sometimes red. Some varieties occur in the form of pisolitic nodules of small size, and in other cases there are irregular cavities between each individual nodule. Exceptional portions of the rock are brecciated, and contain angular fragments of limonite, in a ferruginous clayey matrix. The area which the deposit covers is extensive; the character of the conglomerate is virtually the same throughout, but in one or two places what may be called the ironstone-breccia form occurs, but it appears to be merely local. The thickness of the deposit has so far not been proved; one excavation due North of the railway line has penetrated the conglomerate to a depth of 10 feet without reaching the underlying rocks. An analysis of what may be termed an average sample of the ore yielded only 12·1 per cent. of iron, whilst an exceptional portion returned 44·2 per cent. of metallic iron.

Greenbushes.—About two thousand tons of limonite (laterite ore) have been raised from a deposit occurring on the North of the railway station, and it has been used for fluxing purposes at the Fremantle Smelting Works.

Wongan Hills.—An extensive deposit of what may be called a lateritic limonite forms a very noticeable feature in the neighbourhood. The deposit originally covered the whole of the Wongan Hills, but extensive denudation has taken place and the iron ore formed part of one continuous formation. The lithological character of the deposit presents all gradations from a ferruginous claystone to pure limonite; the former, however, predominating. The rock itself is very porous, and weathers very readily into caverns and cavities of all sizes, whilst the surface of the rock is covered with a glaze of hydrated oxide of iron of a reddish-brown colour in places. A gradual passage can be noticed in places, from a pure ferruginous claystone to pure limonite. Of the origin of the deposit, it is difficult, with the present meagre evidence to hand, to form any satisfactory opinion. It is not a sedimentary deposit, and as it

passes by insensible gradations into the underlying rocks without any sharp line of demarcation, its formation would seem to have been due to the alteration *in situ* of the rocks beneath, and to the residual concentration of iron oxides by the action of atmospheric changes. The deposit, by reason of the ease with which it could be smelted rather than its richness or purity, might become of some considerable importance were it in a more favourable geographical position.

METEORIC IRONS.

Meteoric Irons are also known in the Colony, but they are more of scientific than of commercial interest. Reference having been made to these in scientific publications not readily accessible in the Colony, it has been deemed advisable to include a brief account of these in connection with the terrestrial iron ores.

Youndegin.—In the month of January, 1884, fragments of a meteorite were discovered at a spot three-quarters of a mile North-West of the summit of Penkarring Rock, in the Youndegin District, about 70 miles East of York. The fragments, four in number, were lying loose on the surface, three of them close together, and the fourth about 15 feet away; they weighed $25\frac{3}{4}$lbs., 24lbs., $17\frac{1}{2}$lbs., and 6lbs. respectively. The pieces seem to have formed portions of a spherical mass. Scattered around the iron were broken pieces (of which 17lbs. were collected) apparently belonging to a shell or outer covering; these consisted of magnetic oxide of iron, and may have been due to the weathering of the meteorite. The vicinity of Youndegin consists of granite and schist, intersected by dykes of quartz, and overlaid in places by a superficial covering of sandstone. The fact that iron ore does not occur near Youndegin would seem to indicate an extra-terrestrial origin for the fragments. The meteorite was analysed by Mr. L. Fletcher, late Keeper of Minerals, British Museum, and found to have the composition shown in the Table 1. The specific gravity, as determined from three small pieces freed from rust, was found to be 7·86, 7·85, and 7·72 respectively. The insoluble cubes on further examination proved to be a form of carbon, like graphite, with which it had characters in common, except form and hardness. To this form of meteoric graphite the name of Cliftonite has been applied.* In addition to this there occurred small quantities of a magnetic mineral in the form of small, thin, lustrous black plates. An analysis showed it to be an alloy of nickel and iron, belonging to the tænite group.†

In 1891 a new meteorite was discovered in the vicinity of Youndegin; it weighed $382\frac{1}{2}$lbs., measured $22\frac{3}{4}$in. in height, $20\frac{1}{2}$in. in width, and $13\frac{1}{4}$in. in its greatest thickness. The meteorite was convex on one side, and concave on the other, while both sides were found to be pitted in a manner similar to that usually observed in

* On a Meteoric Iron found in 1884, in the sub-district of Youndegin, Western Australia, and containing Cliftonite, a cubic form of Graphite. L. Fletcher. Min. Mag., 1887. Vol. VII., No. 34, pp. 121-130.

† On the Cliftonite and Tænite of the Meteoric Iron found in 1884, in the sub-district of Youndegin, Western Australia. L. Fletcher. Min. Mag. Vol. XII., 1899, No. 56, pp. 171-174.

other large masses of meteoric iron.* No analysis would seem to have been made of this.

Another enormous mass of meteoric iron, weighing 2044lbs., is recorded from near Youndegin, but no particulars are available.†

Roebourne.—In 1894, a meteorite was discovered by Mr. H. R. Hester on an alluvial plain 200 miles South-East of Roebourne, and eight miles from the Hamersley Range. The mass is shaped a little like the skull of an eagle; the surface being of a lustrous reddish-brown hue, with the metal showing prominently through it in some places. The mass weighed 19½lbs. The meteorite was analysed by Messrs. Mariner & Hoskins, of Chicago, Ill., and found to have the composition given in Column II. of the table appended.

Ballinoo.—Early in the year 1893, George Demmack, a shepherd, discovered a mass of meteoric iron, weighing 93lbs., on a tributary of the Murchison River, about 10 miles South of Ballinoo. In appearance the mass suggests a huge flattened potato. The original coating of the mass has entirely disappeared, except in the larger and more prominent pittings, and a few small blotches on the smooth parts, where it has a graphitic-black granulated appearance. The oxidised surface is very thin, the metal showing clearly through it on all prominent ridges. Messrs. Mariner & Hoskins, of Chicago, who analysed the sample, reported its composition to be that quoted III. in the Table.

Mooranopin.—In or before 1893 a mass of meteoric iron, weighing 2½lbs., was found by an aboriginal near Mooranopin, 160 miles East of York. Its shape is that of an oblong bar. No analysis has been made of this.‡

Analyses of Western Australian Meteoric Irons.

	1.	2.	3.
Iron	92·67	90·914	89·909
Nickel	6·46	8·330	8·850
Cobalt	0·55	0·590	0·740
Copper	Trace	*Nil*	Trace
Phosphorus	0·24	1·156	0·501
Magnesium	0·42	*Nil*	*Nil*
Manganese	*Nil*	Trace (?)	*Nil*
Sulphur	*Nil*	Trace	Trace
Silicon	*Nil*	0·010	Trace (?)
Carbon	*Nil*	Trace	Trace
Insoluble Cubes	0·04	*Nil*	*Nil*
	100·38	100·00	100·00
Sp. gr.	7·86 to 7·72	7·78	7·8

1, Youndegin; Analyst, L. Fletcher. 2, Hamersley Range; Analyst, Messrs. Mariner and Hoskins. 3, Ballinoo; Analyst, Messrs. Mariner and Hoskins.

* A Large Meteorite from Western Australia. J. R. Gregory, Nature, 1892. Vol. XLVII., pp. 90-92.

† Nature, 1892. Vol. XLVII., p. 469.

‡ Four new Australian Meteorites. H. A. Ward. Am. Journ. Sci. 1898. Vol. V. 4th series, No. 26, pp. 135–140.

The following table gives the output of iron ore within the Colony:—

The Production of Iron Ore in Western Australia.

Year.	Locality.	Ore raised.			Estimated value.			Remarks.
		tons	cwt.	qrs.	£	s.	d.	
1899 ..	Clackline	1540	5	2	...			From data supplied by the General Manager, W.A. Smelting Co., Fremantle.
1899 ..	Coate's Siding ...	4712	9	3	...			
1899 ..	Greenbushes ...	2000	0	0	...			
1899 ...	Werribee	4600	0	0	...			
	Total	12,852	15	1	8,939	11	3	

CHAPTER VIII.

MISCELLANEOUS MINERALS.

Antimony, Zinc, Manganese, Mica, Cobalt, and Asbestos.

Antimony.

"There are some very good lodes of Stibnite (sulphide of antimony) in the Roebourne District, and their value in most cases is greatly increased by the quantity of gold they contain. Few of them have been worked yet, since they have mostly been mistaken for small lead lodes which were not suspected of being rich in gold." *

Zinc.

"Blende, assaying 75 per cent. of zinc, occurs in the Northampton District, and along the face of the Darling Range, associated with galena, but this ore is of no commercial value."*

* H. P. Woodward. *Loc. Cit.*

Manganese.

Manganese has been found in many places in the Colony, as can be seen by a reference to the Mineral Census, Chapter XII. Definite detailed information as to their mode of occurrence is not available. The principal sources of manganese ores are the crystalline schists and allied rocks; some of the lodes traversing these are said to be both of large size and of excellent quality, but it still remains to be proved whether the manganese ores are of any commercial value. Black oxide of manganese is found disseminated, as an accessory mineral, throughout the ironstone deposits in the sandstones of the Kimberley District, but not in any great quantity. Certain of what have been referred to on a previous page as lateritic iron ores have yielded appreciable quantities of manganese, but so far these deposits are of no real economic importance.

Mica.

Mica is probably one of the most widely-diffused minerals in the Colony, but it is only of any real commercial value when it occurs in large sheets or can be obtained in considerable quantities. The mica-producing strata are the crystalline schists and allied rocks, which occupy fully two-thirds of the (geologically) known areas of Western Australia. Generally it is found that the mica-producing rocks are pegmatitic granites, which traverse the crystalline schists, etc., either in the form of dykes, sheets, or lenticular masses, which are often parallel to the foliation of the surrounding strata.

Under the generic term Mica several distinct mineral species are included; they are all characterised by the readiness with which they split into very thin elastic plates. Four of the species are of commercial importance, viz., Muscovite (common or white mica); Phlogopite (amber mica): Biotite (black mica); and Lepidolite (lithia mica). They all occur under somewhat similar geological conditions. Two entirely different classes of mica are marketable. The first and most valuable is sheet mica, which is generally dressed into rectangular pieces of standard sizes, the smallest of which is 2 inches by $1\frac{1}{2}$ inches. The value of sheet mica increases very rapidly with its size, the largest of which may be 8 inches by 10 inches, or perhaps more. One of the most important uses of mica is for the panels of stoves and furnaces, as well as for funnels for lamps and incandescent gas lights; for which purposes it is essential that the mica should be perfectly colourless and transparent, devoid of blemish, and should be flexible. The principal use, however, at the present time, of mica is in connection with various electrical appliances, for which the requirement is non-conductivity, implying a low iron content, and should be capable of withstanding a high temperature without disintegration. Muscovite seems to conform to these requirements more than the other varieties, and is therefore the most important mineral commercially. Lepidolite, owing to its low heat-resisting capacity, is not in great

demand, though it is used to a small extent as a source of lithium. The second marketable variety is scrap mica. The waste from the works where large mica is cut into sheets is sold as "scrap." Scrap mica is ground and used as an ingredient in lubricants for decorative purposes and as an absorbent of nitro-glycerine. An excellent non-conducting covering is formed by quilting finely-divided mica between galvanised wire netting, which forms both a flexible and fire-proof wire netting.

What may be called possible commercial mica is known to occur at the following different places in the Colony:—Nokenena Brook, Northampton; Tambourah, Pilbarra Goldfield; Mullalyup, Darling Ranges; Bindoon; The Mica Mine, Londonderry, Coolgardie Goldfield.

The following are descriptions of such of the deposits of which any definite details are available:—

Darling Ranges.—Mica has been found as far back as 1891, on Bussel's Brook, a small tributary of the Collie River. The mica occurs in granite (? pegmatite) dykes, which do not go down vertically. "These dykes run in a North and South direction. . . Near the surface, as a rule, they are much decomposed, the mica being valueless; but in one or two places hard masses outcrop where the mica is of good quality. . . ." *

Londonderry.—The mica at Londonderry is mined by means of an open cut, along the outcrop of a coarse granite dyke, which intersects the surrounding hornblendic rock. The granite, which at times assumes a pegmatitic structure, is composed of large masses (in some cases weighing as much as a hundred-weight or even more) of orthoclase quartz, lepidolite, and cyanide. Muscovite is developed on a small scale, and is generally well crystallised. The only other mineral visible is chalcedony, which is found filling original holes in the rock. The most important, from an economic point of view, of the constituents of the granite is the lithia mica (lepidolite), which occurs generally in rough radiating bunches, although it occasionally appears as somewhat well-defined crystals.

The greatest size in which it (the mica) is found is 15in. by 12in., but this is exceptional, the average not exeeeding 5in. to 6in. The mineral, when not less than about 1-32nd of an inch in thickness, gives a distinet sherry-red colour when examined by transmitted light, but, in sheets split finer than this, it is difficult to detect colouration. Besides these large sheets, the mica also occurs in long crystals, which, when grouped together, as they frequently are, with the longer axes parallel, present a peculiar scale-like impression. The colour of such specimens varies from a pale pink to a pale green, or is quite eolourless. The cleavage of all the varieties is very perfect. †

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* H. P. Woodward. Annual General Report for the year 1890. Perth: By Authority, 1891; p. 47.

† T. Blatchford. The Geology of the Coolgardie Goldfield. Bulletin No. 3. Perth: By Authority, 1899; p. 37.

About two tons of the mica from this locality have been raised, dressed, and exported, but (probably in consequence of the low fusion point) the mineral does not seem to have found a ready sale. As a result of this, mica-mining at this locality has practically ceased.

Up to the present it does not appear that much mica of marketable value has yet been raised in the Colony. The following table gives the export of mica, as shown by the records in the Customs House:—

The Production of Mica in Western Australia.

Year.	Mica exported.	Estimated Value.			Remarks.
		£	s.	d.	
1892	*	25	0	0	* Not stated.
1893	*	4	0	0	
1894	*Nil*	*Nil*			
1895	*	3	0	0	
1896	*Nil*	*Nil*			
1897	*	209	0	0	
1898	*Nil*	*Nil*			
1899	†	50	0	0	† 13 packages; weight not stated.
Total		**291**	**0**	**0**	

Cobalt.

"Cobaltiferous asbolite has been found to occur at both Norseman and Kanowna, and in both instances associated with gold. At Norseman it occurs in an auriferous quartz vein. No assays have been made of it. At Kanowna it is found abundantly in parts of the deep leads, principally in the 'pug' or bedded kaolin, and the underlying much-weathered schists; but also occurs in the nodules of magnesite and in other situations in the lead. It is almost invariably studded with minute crystals of gold. A sample of 'pug,' impregnated with asbolite, yielded in assay 7·56 per cent. of metallic cobalt." *

Asbestos.

Asbestos has been found in widely-separated localities in the Colony, but so far, with the possible exception of the mineral from Tambourah, on the West Pilbarra goldfield, most of the mineral discovered in the Colony up to the present time has proved to be actinolite, of so coarsely fibrous a nature as to be practically valueless.

The asbestos from Tambourah turns out to be fibrous chrysotile, identical with the Canadian mineral, which is so much valued. The Tambourah asbestos, unlike most of the Australian mineral,

* E. S. Simpson, Annual Progress Report of the Geological Survey for the Year 1899.

has not the great defect of a low tensile strength, and in all the points—infusibility, softness, flexibility, fineness, and the ease with which the fibres can be separated—is well above the average. No scientific examination of the district having been undertaken, no information as to the mode of occurrence of the mineral is available.

The Production of Asbestos in Western Australia.

Year.	Asbestos exported.	Estimated value.	Remarks.
	Tons cwts. qrs.	£ s. d.	
1899 ...	*	1 0 0	* One package ; weight not stated.

CHAPTER IX.

COAL AND GRAPHITE.

Coal.—General—Irwin River Coalfield, Collie Coalfield, The Vasse, Fly Brook, Kimberley, Brown Coals of the South Coast.

Graphite.—Champion Bay, Kendenup, Donnelly River.

So far as observations have at present been carried, the coalfields of the Colony fall into three main divisions, viz., the carboniferous rocks of the Irwin, the mesozoic beds of the Collie, the Vasse, and Fly Brook, and the brown coals of the South Coast. It is, however, from the mesozoic rocks that the bulk of the coal of Western Australia has, up to the present, been derived, though considering the great extension of the undoubted carboniferous beds to the North of the Irwin—which cannot be said to have been either prospected or systematically examined—it is by no means unlikely that valuable seams occur.

The coalfields are described in the order of their geological age, and without reference to their geographical position. This method, though not without its disadvantages, is perhaps the most satisfactory in the present condition of our knowledge.

THE IRWIN COALFIELD.

This coalfield was examined and reported upon by H. P. Woodward in 1895.* The following particulars with reference thereto are culled from his report, whilst the geological map shows the area over which the coal measures occupy the surface :—

"The Irwin Coalfield is situated upon what is generally known as the Upper Irwin, or, in other words, the area drained by the various Eastern branches of the Irwin River. The tract of country lies between 30 and 40 miles from the coast, and is extremely fertile. . . . The carboniferous basin spreads out to the Eastward, covering a fan-shaped area, which is surrounded on most sides by cliffs of horizontally-bedded sandstone, about 200 feet in height, which form the edge of the sandy tableland, and it is at the base of these beds where they rest directly, but generally unconformably upon the shales, that springs break out at several places, which form the principal water supply of the district. . . . Indications of coal were first reported to exist upon the Irwin River by Gregory, in the year 1846, which report was a little later confirmed by the Geologist (Dr. Von Sommer), who stated that there were two seams, six feet and eight feet respectively, and it was upon this report that the Government declared a reserve of 10,000 acres. For over 30 years this important discovery was not investigated further, but in the year 1879 the Legislative Council voted the sum of £100 in order to test the quality of the coal, with which object a shaft was sunk to a depth of 50 feet, in which, although no coal was struck, the indications were considered promising. A little later the Government sent the Rev. C. G. Nicolay, M.A., who reported that on account of the great quantity of water met with in sinking and the poor quality of the coal, the discovery was of no value. The field was therefore abandoned until the year 1888, when Messrs. Bell and Elliot found some fragments of coal in the bed of the North Branch, which proved to be of a very fair quality. These they traced up to their source, which they found to be a seam of about four feet in thickness, into which they put a drive 150 feet down the dip, but although it improved both in size and quality, it did not prove at the time to be of sufficient value to induce them to expend any more money upon its development.

"Another lower seam of smutty coal, about two feet in thickness, was also opened up, and about 10 tons raised, which proved to be of a rather better quality, but work was then discontinued. . . Some more seams were also opened up upon another branch, but they did not prove at the time of any value, on account of there being no local demand for coal, and also because the quality was not good enough for export.

"The carboniferous area spreads out from Mingenew in an Easterly direction, covering an area of about 200 square miles, its greatest length from North to South, from Badgeree Pool, upon

* On the Carboniferous Areas in the Irwin River Basin. Appendix 1: Report of the Department of Mines for the year 1895, pp. 1921. Perth; By Authority: 1896.

the North Branch, to Mt. Scratch, being about 30 miles, while its greatest width, from Mingenew to Marandagry, upon the Lockier River, is about 17 miles. To the North-West this area is bounded by the high sandy tableland which extends away to the Northward as far as the Greenough River. The South is bounded for the most part by the low outcrops of metamorphic rock, which contain many copper lodes; to the Eastward by the bold escarpment of crystalline rocks, flanked by horizontally-bedded Tertiary sandstones, which often present towards the plains vertical cliff faces of as much as 200 feet, particularly where streams have cut deep channels through them; whilst to the Westward it is bounded by more high sandy plains which extend as far as the coast. Of these boundaries that to the South and East may be taken as the definite edges of the carboniferous formation, but that to the North and West only as provisional, since the sandstones which form the high sand plain in these directions are of a much more recent date, and may overlie extensions of the carboniferous formation, and since it is known that carboniferous rocks occur in the river valleys further to the Northward it is highly probable that they are part of the same formation; and if this should prove to be the case valuable coal deposits may be found beneath the high sand plains which lie between the Irwin, Greenough, and Murchison Rivers."

The Coal Measures consist of a series of shales, sandstones, and limestones, which are very rich in marine fossils.

So far as researches have at present been carried, no estimate of the thickness of these beds has been found possible.

The coal seams are said to occur in these beds intimately associated with carbonaceous shales. The coal is dirty to the touch, and, owing to the relatively high percentage of water, it rapidly decrepitates on exposure to the atmosphere.

The following table shows the analyses of the Irwin River coals:—

Chemical Analyses of Coals from the Irwin River Basin.

No. of Analysis.	Description of Sample.		Analyst.	Moisture.	Volatile Hydro-carbons.	Fixed Carbon.	Ash.	Sulphur.
1	Irwin Coal Seam	... ...	Mr. Harland (London)	17·04	28·61	41·29	13·06	
2	Do.	... ...	Mr. Wingham (London)	12·4	32·2	43·5	11·9	0·83
3	Do.	... ...	B. H. Woodward ...	15·63	23·06	39·32	21·99	
4	Do.	Top ...	Assayer Waneranooka Mine Northampton	26·50	16·00	57·50		0·15
5	Do.	Middle	do.	23·00	18·00	59·00		0·10
6	Do.	Bottom	do.	23·00	18·00	59·00		0·10
	Mean of Six Samples		... ...	**19·59**	**22·64**	**57·76**		**0·19**

A series of bores were put down by the Midland Railway Company, but no record appears to have been kept of the strata pierced. The deepest bore is said to have attained a depth of about 500 feet, but, as the work was stopped in black shale, before the base of the beds had been reached, very little useful information resulted.

Having in view the delimitation of the Westward boundary of the Irwin River Coal Measures, a bore was put down by the Government at Dongara. The bore attained a depth of 2,111 feet 7 inches, when operations were stopped owing to the capabilities of the boring plant being exhausted, without having proved the presence of the Irwin River beds.

The following is a section of the strata pierced as compiled from the bore journals supplied by the Department of Public Works:—

Dongara Bore.

Nature of Strata.	Thickness.		Depth.		Formation.
	ft.	in.	ft.	in.	
Sand	6	0	...		Coastal Limestone
Clay	3	6	6	0	Do.
Sandstone	50	6	9	6	Do.
Limestone	12	0	60	0	Do.
Sandstone	23	0	72	0	Do.
Clay	45	0	95	0	Do.
Micaceous Sandstone ...	90	0	140	0	Mesozoic
Drift Sand (Incoherent Sandstone ?)	30	0	230	0	Do.
Sandstone with Coal Seams	45	0	260	0	Do.
Carbonaceous Shale ...	4	0	305	0	Do.
Sandstone	110	0	309	0	Do.
Sandstone with veins of Coal	15	4	419	0	Do.
Sandstone	42	8½	434	4	Do.
Sandstone with bands of Carbonaceous Shale	12	9	477	0½	Do.
Sandstone	42	11	489	9½	Do.
Grey Shale...	2	0	532	8½	Do.
Sandstone	705	11½	534	8½	Do.
Shale...	9	11	1,240	8	Do.
Sandstone with thin Shale band	124	10	1,250	7	Do.
Micaceous Shale	28	7	1,375	5	Do.
Sandstone	88	6	1,404	0	Do.
Shale...	57	3	1,492	6	Do.
Sandstone	100	0	1,549	9	Do.
Micaceous Shale	82	7	1,649	9	Do.
Sandstone	379	3	1,732	4	Do.
Total	2,111	7	2,111	7	

At a depth of 149 feet, water was met with in a bed of sandstone, and stood at 17 feet from the surface. On further boring to a depth of 935 feet the water rose within 2 feet 6 inches of the

surface. When operations had reached 1,023 feet in a coarse, grey sandstone, the water rose to the surface. The first overflowing supply was encountered in a micaceous sandstone at a depth of 1,259 feet 7 inches, the yield being 128 gallons per hour; this flow increased to 240 gallons per hour at a depth of 1,327 feet, the water being obtained from a bed of micaceous sandstone. Fresh water, flowing at the rate of 3,600 gallons per hour, was met with at 1,384 feet. The water, which is said to have flowed from a micaceous shale, issued with a temperature of 98 degrees, and rose 22 feet above the surface.

An analysis of a 4-inch seam occurring at 265 feet, carried out in the official laboratory, showed its composition to be in parts per hundred :—

Moisture	13·13
Volatile Hydro-carbon	29·47
Fixed Carbon	49·40
Ash...	8·00

THE COLLIE COALFIELD.

The Collie Coalfield is situated about 25 miles due East of Bunbury, upon the Collie River, at an altitude of about 600 feet above sea level. The Collie River rises in that elevated tableland between the head of the Murray and the Blackwood, and, after flowing generally North-West, enters the sea at Leschenault Inlet, to the North of the town of Bunbury. The existence of a coalfield has been known since somewhere about the year 1890, although coal would seem to have been discovered some six years before.

The Collie field covers an area of about 12 miles in length, in a North-West and South-East direction, with a width of about four miles; it embraces an area of about 50 square miles. The field is traversed through its whole length by the North and South branches of the Collie River, and is connected by rail with the main railway system of the Colony.

The Coal Measures consist of a series of sandstones conglomerates, shales, and coal seams, but, owing to the peculiarities of the basin, the measures are however seldom visible at the surface, being covered by a more recent deposit derived from the weathering, *in situ*, of the beds beneath. This recent deposit is often cemented together by oxide of iron, forming what is locally designated as ferruginous conglomerate. The Coal Measures readily decompose into a sandy soil, which contributes in no small measure to the concealment of the underlying rocks.

Any visible outcrops of the Coal Measures are found only along lines of most rapid erosion, and that is along the water-courses. At several places in the bed of the Collie River, just below the water-level, in the vicinity of Coal Mining Lease 110, are apparently horizontally bedded sandstones belonging to the Coal Measures.

The Coal Measures have been deposited in a comparatively unsymmetrical shallow basin of erosion. Cases occur in which a portion of the seams has been eroded, and the channel so formed filled with deposits of sand. The strata do not appear to have been subjected to any serious disturbance, and to have suffered little or no lateral pressure. So far as mining operations have at present been carried, the beds all dip at a comparatively low angle into the basin. This low dip may, in part, be due to the changes produced by the consolidation and the settling of the strata in the basin in which the vegetable and other matter was deposited. During this process, the more unyielding material beneath the coal would have a tendency to produce those "rolls" so common in some parts of the field. The effects of this settling are shown by the small faults, in reality cracks, which have been discovered in the course of the workings along the edge of the coal basin.

Mining operations have, so far, shown that workable seams appear to be confined to the series of sandstones and shales that constitute the sixty or seventy feet below the level of the bed worked in the Government mine, now better known as the Wallsend Colliery. These seams are within comparatively easy reach of the surface along the Northern periphery of the basin, as has been proved by the records of the hand bores put down at the instance of the Government, under the direction of Mr. W. B. Pendleton. In all, 18 bores were put down. The following tables show the results obtained :—

Record of Strata pierced by Pendleton's Hand Boring Plant.

No. of Bore.	Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.
1	Measures ..	37	0	...	
	Coal ...	0	9	37	0
	Measures ...	12	10	37	2
	Total ...	50	0	50	0
2	Measures ...	2	9	...	
	Coal ...	3	10	2	9
	Measures ...	13	5	6	7
	Total ...	20	0	20	0
3	No data; running sand.				
4	Measures ...	40	0	...	
	Coal ...	17	11	40	0
	Measures ...	6	1	57	11
	Coal ...	1	7	64	0
	Measures ...	54	5	65	7
	Coal ...	0	3	120	0
	Measures ...	3	9	120	3
	Coal ...	4	0	124	0
	Measures ...	2	0	128	0
	Coal	2	9	130	0
	Measures ...	19	3	132	9
	Coal ...	4	0	152	0
	Measures ...	11	0	156	0
	Coal ...	2	0	167	0
	Measures ...	3	0	169	0
	Coal ...	3	6	172	0
	Measures ...	2	6	175	6
	Coal ...	0	2	178	0
	Measures ...	20	0	180	0
	Total ...	200	0	200	0

Record of Strata pierced by Pendleton's Hand Boring Plant—continued.

No. of Bore.	Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.
5	Measures ...	10	0	10	0
	Coal ...	11	3	10	0
	Total ...	21	3	21	3
6	Measures ...	42	0	...	
	Coal ...	1	0	42	0
	Measures ...	19	0	43	0
	Coal ...	7	0	62	0
	Measures ...	22	0	69	0
	Coal ...	2	0	91	0
	Measures ...	9	0	93	0
	Coal ...	1	0	102	0
	Measures ...	24	0	103	0
	Coal ...	7	6	127	0
	Measures ...	1	6	134	6
	Total ...	136	0	136	0
7	Measures ...	184	0	184	0
	Total ...	184	0	184	0
8	Measures ...	123	0	...	
	Coal ...	11	0	123	0
	Measures ...	16	0	134	0
	Total ...	150	0	150	0
9	Measures ...	58	0	...	
	Coal ...	0	11	58	0
	Measures ...	51	1	58	11
	Coal ...	8	4	110	0
	Measures ...	75	8	118	4
	Total ...	194	0	194	0
10	Measures ...	77	0	...	
	Coal ...	1	0	77	0
	Measures ...	8	0	78	0
	Coal ...	2	0	80	0
	Measures ...	165	0	82	0
	Total ...	245	0	245	0
11	Measures ...	17	0	...	
	Coal ...	12	0	17	0
	Measures ...	1	0	29	0
	Total ...	30	0	30	0
12	Measures ...	18	0	...	
	Coal ...	22	2	18	0
	Measures ...	0	10	40	2
	Total ...	41	0	41	0
13	Measures ...	15	0	...	
	Coal ...	6	10	15	0
	Measures ...	4	2	21	10
	Coal ...	9	6	26	0
	Measures ...	27	6	35	6
	Total ...	63	0	63	0
14	Measures ...	40	0	...	
	Total ...	40	0	40	0
15	Measures ...	44	0	...	
	Coal ...	0	7	44	0
	Measures ...	13	5	44	7
	Coal ...	6	0	58	0
	Measures ...	16	0	64	0
	Coal ...	1	4	80	0
	Measures ...	2	8	81	4
	Total ...	84	0	84	0
16	Measures ...	53	0	...	
	Coal ...	1	2½	53	0
	Measures ...	37	9½	54	2½
	Coal ...	10	1	92	0
	Measures ...	12	11	102	1
	Coal ...	0	7½	115	0
	Measures ...	51	4½	115	7½
	Coal ...	4	3	167	0
	Measures ...	1	9	171	3
	Coal ...	4	8	173	0
	Measures ...	15	4	177	8
	Coal ...	2	10	193	0
	Measures ...	28	2	195	10
	Coal ...	5	0	224	0
	Measures ...	1	0	229	0
	Coal ...	9	9½	230	0
	Measures ...	10	2½	239	9½
	Total ...	250	0	250	0

Record of Strata pierced by Pendleton's Hand Boring Plant—continued.

No. of Bore.	Nature of Strata.	Thickness.		Depth.		No. of Bore.	Nature of Strata.	Thickness.		Depth.	
		ft.	in.	ft.	in.			ft.	in.	ft.	in.
17	Measures ...	35	0	...		18	Measures ...	47	0	...	
	Coal ...	0	3	35	0		Coal ...	1	1	47	0
	Measures ...	9	9	35	3		Measures ...	16	11	48	1
	Coal ...	0	1	45	0		Coal ...	3	4	65	0
	Measures ...	55	5	46	0		Measures ...	16	8	68	4
							Coal ...	1	6	85	0
	Total ...	101	0	101	0		Measures ...	12	6	87	6
							Total ...	100	0	100	0

The coal seams vary in thickness from that of a sheet of paper up to about 13 feet. The coals are hydrous, non-caking, and bituminous; they approach very closely to lignites in some parts. Between the two varieties the differences are only of degree, for there are really no distinctive characters which would find universal application. Owing to the conditions of deposition the coals naturally vary in character, and in places pass insensibly through forms containing a large proportion of earthy matter to carbonaceous shales.

The analyses in the table appended may, with the exception of No. 21 (which is, in reality, a very carbonaceous shale), be regarded as representative of the commercial coals of the field. The water contents of the coal vary from 7 to a little over 15 per cent. The average percentage of volatile hydro-carbons is about 30, but shows a variation from 21 to 35 per cent. The fixed carbon fluctuates between 27 to 56 per cent., but has an average of about 49·08. The ash of the coal does not, so far, appear to possess any peculiarities; the analyses show that it ranges between 1 and 33 per cent., but amounts in the average to about 8·62 parts per hundred.

Chemical Analyses of Coals from the Collie River Basin.

No. of Analysis.	Description of Sample.	Analyst.	Specific Gravity.	Calorific Value. Pounds evaporated.	Calorific Value. British Thermal Units.	Percentage Composition. Moisture.	Volatile Hydro-carbons.	Fixed Carbon.	Ash.	Sulphur.
1	Pendleton's Shaft near T. 26	B. H. Woodward, February, 1893	...	7·70	7·440	7·94	29·70	55·75	6·61	*Nil*
2	Do. do.	Do. April, 1893 ...	...	7·70	7·440	13·30	22·08	56·36	8·26	*Nil*
3	Near T. 26, a few feet deep	Royal School of Mines, March, 1890	...	...	...	12·75	37·04	46·70	2·80	0·71
4	First sample from River bed	B. H. Woodward, November, 1889	...	...	...	15·20	32·46	45·03	5·08	2·23
5	Same seam, 17ft. deep	Do. April, 1890 ...	...	...	...	10·87	31·47	52·87	2·56	2·23
6	Do. top	Do. October, 1891 ...	...	6·06	5·910	13·65	34·88	48·35	3·12	1·09
7	Do. bottom	Do. do. ...	...	6·06	5·910	13·85	35·90	45·93	4·32	1·18
8	Outcrop at T. 17	Do. April, 1890 ...	...	...	...	11·70	21·83	54·17	9·31	2·99
9	Diamond Drill Bore No. 2, 2ft. 7in. seam, 61ft. from surface ...	Do. January, 1895...	...	...	...	11·00	33·98	52·83	2·19	
10	Do. do. 8ft. 3in. seam, 133ft. from surface ...	Do. do. ...	...	...	...	11·27	32·76	53·51	2·46	
11	Government Mine, 100ft. deep; not air-dried	Do. May, 1895 ...	...	7·26	7·080	14·50	34·69	49·07	1·74	Trace
12	Do. do. air-dried	Do. do. ...	1·291	6·03	5·290	11·40	35·94	50·85	1·81	0·53
13	Seam 5 miles West at T. 17; not air-dried	Do. do. ...	...	...	...	13·00	35·15	48·54	3·31	Trace
14	Do. do. air-dried	Do. do. ...	1·308	...	...	7·00	35·57	51·89	3·54	
15	Hay's 3ft. seam	Do. February, 1895	...	...	...	9·37	33·46	50·94	6·23	Trace
16	Government Mine, 16ft. seam, 100ft. from surface	D. A. Sutherland, August, 1895 ...	1·408	10·12	9·780	11·75	24·74	56·43	6·85	0·23
17	Do. do. do.	Johnson & Sons, do. ...	1·287	...	...	11·50	23·74	56·98	7·42	0·36
18	G.S.M. 247, West Collie Proprietary; air-dried for six months	E. S. Simpson, November, 1897 ...	1·211	12·10	11·700	10·93	32·86	52·87	3·34	0·59
19	G.S.L. 535	Do. April, 1898 ...	1·356	10·40	10·050	13·95	27·89	52·25	5·91	0·44
20	G.S.M. 718, West Collie Proprietary; Top Coal	Do. July, 1898 ...	1·327	11·55	11·120	12·07	31·75	48·10	8·08	2·00
21	G.S.M. 719, do. band below Top Coal ...	Do. do. ...	1·565	7·15	6·910	9·10	27·18	33·85	29·87	0·10
22	G.S.M. 720, do. Bottom Coal	Do. do. ...	1·417	10·45	10·090	10·60	26·00	46·85	16·55	0·39
23	G.S.M. 721, Collie Proprietary	Do. do. ...	1·409	10·12	9·780	13·98	25·82	53·51	6·69	0·05
24	G.S.M. 722, heap at surface, Government Mine	Do. do. ...	1·419	11·15	10·740	12·03	25·65	54·78	7·54	0·10
25	G.S.L. 715, West Collie Proprietary, A1	Do. August, 1898 ...	1·267	11·82	11·430	14·57	36·61	44·80	4·02	
26	G.S.L. 710 do. A	Do. do. ...	1·319	11·16	10·790	13·87	32·62	45·63	7·88	
27	G.S.L. 711 do. B	Do. do. ...	1·356	10·61	10·270	11·22	29·58	44·89	14·31	
28	G.S.L. 712 do. C	Do. do. ...	1·436	10·50	10·150	10·73	28·35	45·05	15·87	
29	G.S.L. 713 do. D	Do. do. ...	1·448	9·73	9·410	10·98	25·58	45·33	18·11	
30	G.S.L. 714 do. E	Do. do. ...	1·468	9·52	9·200	10·33	25·48	45·63	18·56	
31	G.S.L. 716 do. E2	Do. do. ...	1·525	9·90	9·570	8·94	29·61	27·57	33·88	0·37
32	West Collie Proprietary; average used on Locomotive trials, January, 1898	E. A. Mann, January, 1898 ...	...	11·69	11·300	7·63	34·94	45·84	11·59	0·90
33	G.S.M. 1090, Wallsend Colliery (late Government Mine) ...	E. S. Simpson, February, 1899 ...	1·368	9·95	9·610	15·05	24·95	53·30	6·70	0·23
34	G.S.M. 1091, do. do.	Do. do. ...	1·408	10·18	9·830	14·17	26·63	52·43	6·77	0·19
	Mean of thirty-four samples		**1·379**	**9·53**	**9·200**	**11·77**	**30·20**	**49·08**	**8·62**	**0·84**

The seam upon which operations have so far chiefly been centred is that outcropping in the bed of the river on the Southern boundary of Coal Mining Lease 85, near T. 26; it is worked by a tunnel driven along the seam, in a general Southerly direction, for a distance of about 1,407 links. The dip of the seam is about eight degrees to the Southward. An air shaft has been put down some distance from the mouth of the tunnel, and intersected the seam at a depth of 41 feet from the surface. The shaft was carried down a further distance of 74 feet.

The section in the shaft is as follows :—

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Measures *	23	6	...	
Coal	0	2	23	6
Measures	0	9	23	8
Coal	2	10	24	5
Measures	1	3	27	3
Coal	12	6	28	6
Measures	6	4	41	0
Coal	2	6	47	4
Measures	66	1	49	10
Total	115	11	115	11

It is estimated that had this shaft been continued a further distance of about 8 feet, the 4-feet seam reported at 124 feet, No. 4 Hand Bore (*Vide supra*), would have been met with.

Number 4 Diamond Drill Bore, which has been put down about 50 chains South-West from the Government Mine, intersects that seam at a depth of 616 feet. The section which has been compiled from the bore journals gives a complete section for about 600 feet above the level of the Government mine seam, and about 300 feet below it. The record also shows a 4-feet seam of coal lying about 46 feet beneath the Government mine seam, and also another of equal thickness of about 100 feet lower down.

The uppermost 4-feet seam may be correlated with the 4-feet seam which the section in No. 4 hand bore shows to exist about 80 feet below the mine seam. It is noteworthy that No. 9 Hand Bore was met with in No. 4 Diamond Drill Bore which is situated some little distance to the West.

* Full details as to the nature of the measures in this and subsequent tables will be found on pp. 13-21 of the Annual Progress Report of the Geological Survey for the Year 1898. Perth; By Authority: 1899.

No. 4.—*Diamond Drill Bore.*
580 feet above Sea Level.

Nature of Strata.	Thickness.		Depth.		Remarks.
	ft.	in.	ft.	in.	
Measures	406	5	...		Artesian water commenced to flow at 80 feet in depth from a bed of grey sandstone in this bore; as the work was continued, the supply gradually increased until the grey sandstone was reached at a depth of 634 feet, when it was flowing at the rate of 15,000 gallons per diem; and, when boring operations ceased, water was flowing at the rate of 25,000 gallons per day.
Coal	0	9	406	5	
Measures	87	8	407	2	
Coal	0	6	494	10	
Measures	92	9	495	4	
Coal	11	0	588	1	
Measures	10	8	599	1	
Coal	3	0	609	9	
Measures	3	6	612	9	
Coal	13	4	616	3	
Measures	32	10	629	7	
Coal	4	0	662	5	
Measures	96	7	666	5	
Coal	4	0	763	0	
Measures	22	1	767	0	
Coal	2	8	789	1	
Measures	109	1	791	9	
Total ...	900	10	900	10	

Between the outcrop of the Government Mine seam and the granitic rocks to the North, two shafts have been put down by a South Australian syndicate, with the object of testing the measures below the seam. No record would, however, seem to have been kept of the strata pierced by the shafts.

Shaft No. 1, on Coal Mining Lease 85, so far as can be judged by the material lying at grass, appeared to pass through white, gritty sand (fine conglomerate?), associated with the Coal Measures. The most Northerly shaft, No. 2, entered, after penetrating the superficial cover of ferruginous conglomerate, the crystalline rocks which form the floor of the basin.

Diamond Drill Bore No. 2, on the North bank of the Collie River, on Coal Mining Lease 100, of which the section exposed is appended, pierced an 8-feet seam of coal at a depth of 127 feet from the surface.

No. 2—*Diamond Drill Bore.*
587 feet above Sea Level.

Nature of Strata.	Thickness.		Depth.		Remarks.
	ft.	in.	ft.	in.	
Measures	55	1	...		A fine stream of artesian water, yielding about 50,000 gallons per diem, flows from this bore.
Coal	2	7	55	1	
Measures	69	7	57	8	
Coal	8	3	127	3	
Measures	103	$5\frac{1}{2}$	135	6	
Coal	0	2	238	$11\frac{1}{2}$	
Measures	6	8	239	$1\frac{1}{2}$	
Coal	0	10	245	$9\frac{1}{2}$	

No. 2—*Diamond Drill Bore*—continued.

Nature of Strata.	Thickness.		Depth.		Remarks.
	ft.	in.	ft.	in.	
Measures	62	10	246	7½	
Coal	0	8	309	5½	
Measures	4	7½	310	1½	
Coal	0	4	314	9	
Measures	1	7	315	1	
Coal	0	2	316	8	
Measures	3	8	316	10	
Coal	0	4½	320	6	
Measures	4	6½	320	10½	
Coal	0	6½	325	5	
Measures	42	3½	325	11½	
Coal	0	8	368	3	
Measures	64	1	368	11	
Coal	0	9	433	0	
Measures	296	9	433	9	
Coal	1	0	730	6	
Measures	45	0	731	6	
Coal	1	0	776	6	
Measures	172	9	777	6	
Coal	1	3	950	3	
Measures	0	4	951	6	
Total ...	951	10	951	10	

Some little distance to the West of the Wallsend Colliery, a private diamond drill has been used to test the measures to a depth of 500 feet. The bore is situated near the South-Eastern corner of Coal Mining Lease 105. The following is a record of the strata pierced :—

Calyx Drill Bore, West Collie Coal Proprietary Company, Coal Mining Lease 105.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Measures	157	0	...	
Coal	2	0	157	0
Measures	40	8	159	0
Coal	0	6	199	8
Measures	20	4	200	2
Coal	0	3	220	6
Measures	20	9	220	9
Coal	0	2	241	6
Measures	37	4	241	8
Coal	3	0	279	0
Measures	69	7	282	0
Coal	2	0	351	7
Measures	18	1	353	7
Coal	2	8	371	8
Measures	12	7	374	4
Coal	6	0	386	11
Measures	110	6	392	11
Total	503	5	503	5

There appears to be no coal at all comparable with that in the Wallsend Colliery in this section, unless the seams have thinned out considerably in this direction, or a fault passes between the two localities.

The strata at the Western end of the field, where the discovery of coal was first made, have been tested by means of shafts and bore holes. Number 7 Diamond Drill Bore near the Northern edge of the basin, as can be seen by the section, attained a depth of 528 feet, and passed through but one seam of coal nine inches thick.

No. 7.—*Diamond Drill Bore.*

Altitude, 591 feet above Sea Level.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Measures	268	0	...	
Coal	0	9	268	0
Measures	259	3	268	9
Total	528	0	528	0

Further to the West, No. 6 Diamond Drill Bore penetrated to a depth of 424 feet below the surface, and passed through six seams of coal, the largest being returned as 5 feet 6 inches in thickness.

No. 6.—*Diamond Drill Bore.*

Altitude, 580 feet above Sea Level.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Measures	38	1	...	
Coal	1	5	38	1
Measures	22	4	39	6
Coal	0	6	61	10
Measures	17	2	62	4
Coal	5	6	79	6
Measures	107	6	85	0
Coal	0	6	192	6
Measures	9	6	193	0
Coal	1	0	202	6
Measures	6	6	203	6
Coal	1	6	210	0
Measures	212	6	211	6
Total	424	0	424	0

A short distance due South of this Bore, a vertical shaft has been put down to a depth of 135 feet, of which the following particulars have been supplied :—

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Measures	25	0	..	
Coal	0	7	25	0
Measures	31	3	25	7
Coal	0	3	56	10
Measures	1	1	57	1
Coal	0	10	58	2
Measures	28	4	59	0
Coal with Carbonaceous Shale bands	2	6	87	4
Measures	12	3	90	10
Data incomplete	...		...	

Between the roof and the floor of the seam worked is said to be 14 feet. Seventeen feet above this seam is another, showing 18 inches of coal, and 18 inches of shale.

On Coal Mining Leases 86 and 89 a good deal of exploring has been done. A seam of coal has been worked from the outcrop by an inclined shaft. The section of the seam (Collie Proprietary) is as follows :—

	Feet.	Inches.	
Coal	4	6	Top seam.
Shale	1	4	
Coal	0	2	
Clay Band	0	2	
Sandstone	4	9	
Carbonaceous Shale	2	0	
Coal	2	3	Bottom Seam.
Carbonaceous Shale	0	6	
Coal	2	6	

Two hand bores have been put down to the Eastward of the inclined shaft, and pierced the seams at 30 and 43 feet respectively.

The strata passed through are as follows :—

Bore on Coal Mining Lease No. 89, 86 yards East from the mouth of the Day-hole.

Nature of Strata.		Thickness.		Depth.	
		ft.	in.	ft.	in.
Measures ...		30	0	...	
Coal	Top Seam	6	0	30	0
Black Shale	Top Seam	1	0	36	0
Coal	Top Seam	1	0	37	0
Measures ...		6	0	38	0
Coal ...	Bottom Seam	8	0	44	0
Measures ...		14	0	52	0
Total ...		66	0	66	0

The following is a section of the strata pierced in the hand bore on Coal Mining Lease 89, distant 89 yards to the South-East of the tunnel above mentioned :—

Bore on Coal Mining Lease 89.

Nature of Strata.		Thickness.		Depth.	
		ft.	in.	ft.	in.
Measures ...		14	0	...	
Coal (smut)		2	0	14	0
Measures ...		27	2	16	0
Coal ...	Top Seam	4	6	43	2
Black Shale bands	Top Seam	0	6	47	8
Coal ...		1	4	48	
Measures ...		5	11	49	
Coal	Bottom Seam	2	3	55	
Shale	Bottom Seam	0	6	57	
Coal	Bottom Seam	2	9	58	
Measures ...		1	0	60	11
Total ...		61	11	61	11

The coal met with in Government Hand Bores 13 and 14 to the North of the main workings are probably on a lower horizon than the Collie Proprietary seam. No. 13 Hand Bore penetrated two seams, the first about seven feet thick at a depth of 15 feet, and the 9 feet 6 inches seam at a vertical depth of 26 feet below the surface. About 15 chains East of this is No. 14 bore, which was carried down 84 feet 2 inches, when a seam of coal was met with; its thickness was never tested, owing to the abandonment of the bore. The seams in No. 3 Hand Bore may probably be those shown in No. 4 Diamond Drill Bore at 609 and 616 feet respectively; these being the only coals at all comparable with them.

The centre of the coal basin has been explored by means of Diamond Drill Bore No. 3, down to a depth of 270 feet, and

several seams of coal met with. The section of this bore is as follows:—

No. 3.—*Diamond Drill Bore.*

592 feet above Sea Level.

Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.
Measures	35	0	...	
Coal	2	$8\frac{1}{2}$	35	0
Measures	66	6	37	$8\frac{1}{2}$
Coal	0	3	106	$2\frac{1}{2}$
Measures	40	6	106	$5\frac{1}{2}$
Coal	1	5	146	$11\frac{1}{2}$
Measures	10	$7\frac{1}{2}$	148	$4\frac{1}{2}$
Coal	5	0	159	0
Measures	13	$9\frac{1}{2}$	164	0
Coal	2	$3\frac{1}{2}$	177	$9\frac{1}{2}$
Measures	44	2	180	1
Coal	0	7	224	3
Measures	11	$5\frac{1}{2}$	224	10
Coal	0	6	236	$3\frac{1}{2}$
Measures	33	6	236	$9\frac{1}{2}$
Total	270	$3\frac{1}{2}$	270	$3\frac{1}{2}$

The Northern outcrop of the field, just to the North of Coal Mining Lease 171, was explored by No. 1 Diamond Drill Bore, and the granite beneath the sedimentary beds met with at a depth of 417 feet. No coals were met with. The strata are obviously on a lower horizon than those with which the coals are associated at Wallsend.

Diamond Drill Bore No. 5 was sunk to a depth of 96 feet, some little distance outside the Western edge of the Coal Measures. The bore passed through 91 feet of superficial deposits, and penetrated 5 feet into an olivine diorite, when operations ceased.

The Collie Coalfield being situated in a comparatively small basin at some considerable elevation above the Coastal Plain, it is by no means improbable that similar areas exist along the coast, where the physical conditions are favourable to the deposition of coal seams. That such a condition is highly probable is shown by the fact that in places along the range fragments of strata identical with those on the Collie are seen resting directly upon the underlying rocks. It is reported that many years ago, what was reputed to be a seam of coal was met with in one of the branches of the Preston, eight miles from Bunbury, at a place called the "Coal Pits." Two bores were put down, and in one of them 12 inches of good coal were obtained; no record would, however, seem to have been kept of the strata pierced in these bores.

With the object of testing the country beneath the Coastal Plain in this district, a Calyx Drill Bore was put down to a depth of 1016 feet * on the Dardanup Estate. The strata pierced consisted

* 24th January, 1900.

chiefly of sands, clays, sandstones, and shales. A seam of bituminous coal was met with at 150 feet from the surface, the bed being 6 inches in thickness; at 452 feet another seam of 5 inches was pierced. The bore is still in progress.

An analysis of the coal from Dardanup was made in the official laboratory, with the following result:—

Moisture	14·36
Volatile Hydro-carbons	35·89
Fixed Carbon	64·14
Ash	3·61
	118·00

It is not known from which of the two seams the sample was obtained.

THE VASSE.

A good deal of experimental boring has been carried out since the year 1892 in the neighbourhood of the Vasse River, which enters Geographe Bay near Wonnerup, some miles to the North of Cape Naturaliste.

In all there have been six recorded bores, in the whole of which 25 coal seams have been reported. The greatest thickness of coal in any one bore was about 3 feet 6 inches. No analyses of the most promising of the beds appear to have been made. In two bores only does the floor of crystalline rocks, upon which the strata were laid down, appear to have been met with.

So far as may be judged from the bore journals, the strata consist largely of sand—in all probability an incoherent sandstone—shales, with pyritous nodules, and dark and yellow clays. They in all probability represent the Northward continuation of the Fly Brook beds.

The following tables give such particulars with reference to the coals passed through as are available:—

No. 1.—*Section of Bore six miles from Busselton on the Vasse River.*

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Measures	19	0	...	
Coal	3	0	19	0
Measures	137	0	22	0
Total	159	0	159	0

The seam of coal in this bore is said to be the same as that met with at 93 feet 6 inches in Bore No. 3. This bore also penetrated mixtures of coal and clay at different depths.

No. 2.—*Section of Bore five miles from Busselton, at the Vasse.*

Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.
Measures	88	7	...	
Coal	3	0	88	7
Measures	52	0	91	7
Total	143	7	143	7

No. 3.—*Section of Bore four miles from Busselton, on Fairlawn Estate.*

Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.
Measures	93	9	...	
Coal	1	1*	93	9
Measures	31	8	94	10
Coal	0	7	126	6
Measures	19	1	127	1
Coal	1	2	146	2
Measures	27	10	147	4
Coal	3	5½	175	2
Measures	69	4½	178	7½
Coal	...		248	0
Measures	21	2	...	
Total	269	2	269	2

No. 4.—*Section of Bore five miles from Busselton.*

Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.
Measures	96	0	...	
Coal	2	0	96	0
Measures	18	0	98	0
Coal	4	0	116	0
Measures	62	0	120	0
Coal	1	0	182	0
Measures	57	0	183	0
Coal	1	0	240	0
Measures	6	0	241	0
Coal	1	6	247	0
Measures	21	0	248	6
Coal	1	6	269	6
Measures	161	0	271	0
Coal	2	0	432	0
Measures	12	2	434	0
Total	476	2	476	2

* This seam of coal is said to be the equivalent of that met with at 19 feet in Bore No. 1.

No. 5.—*Section of Bore six miles from Busselton, on the Vasse River.*

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Measures	53	11	...	
Coal	0	1	53	11
Measures	157	0	54	0
Coal	0	1	211	0
Measures	162	11	211	1
Coal	1	6	374	0
Measures	97	6	375	6
Coal	1	0	463	0
Measures	191	6	464	0
Granite and Gneiss	1	0	655	6
Total	656	6	656	6

No. 6.—*Section of Bore at Newton, near Busselton.*

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Measures	113	0	...	
Coal (inferior)	1	6	113	0
Measures	21	0	114	6
Dark Shale with two four-inch coal bands	2	0	135	6
Measures	69	6	137	6
Coal (inferior)	1	6	207	0
Measures	4	0	208	6
Coal	0	6	212	6
Measures	21	6	213	0
Coal	1	0	234	6
Measures	9	0	235	6
Coal	0	6	244	6
Measures	33	6	245	0
Coal	0	6	278	6
Measures	2	0	279	0
Coal	0	3	281	0
Measures	49	0	280	9
Gneiss	0	3	329	9
Total	330	0	330	0

FLY BROOK.

"The Fly Brook is the furthest branch to the South-East of the Donnelly River, which discharges itself into the Southern Ocean, about 30 miles East of Cape Leeuwin. The river is always running, since there is a large rainfall in this portion of the Colony, but, unfortunately, it is not navigable, besides which the estuary at its mouth is closed by a sand bar; therefore, the nearest ports that ships could use are Augusta and Hamelin Harbour, about 30 miles

to the Westward. On this brook some coal-mining leases were taken up in the year 1888, but the existence of coal seams appears to have been known to some of the older inhabitants for many years. Several reports have been made, which show that four large seams of coal outcrop in the gully. These leases were tested in a systematic manner by a series of bore holes, to determine the number, size, quality, and extent of the seams, which were shown to extend over the whole area taken up, the large seams being easily identified when met with in the different holes by their persistent thickness, associated beds, and partings; but up to the present the entire thickness of this formation in the deep ground is unknown since there was so much water in drifts that the bore hole was continually falling in. One of the bores passed through about 20 feet of coal in sinking to a depth of 128 feet, consisting of 17 seams, the largest being 5 feet 4 inches with a 6-inch clay parting, 2 feet 4 inches with a 3-inch parting, and 2 feet 3 inches with a 2-inch parting. Other seams, up to a foot in thickness, could also be worked, since several occur close together separated only by shaly partings.

"The coal itself is a highly lustrous variety, having almost the appearance of jet, but lacking its hardness, while the woody structure is clearly visible in some pieces. Upon assay it proves to be almost identical in composition with the cretaceous coals of the Pacific coast of North America.

"The average of three samples of Fly Brook coal assayed in Melbourne and Adelaide is:—

Water	16·40
Volatile matter	38·23
Fixed Carbon	43·32
Ash	1·85

As the similar coal in America is used largely for steam and other purposes, there is no reason why this should not prove to be of value in the future. The distance from a port is a great drawback, whilst the large percentage of water the coal contains renders it too friable for much handling. It may be mentioned that the samples sent away were no test since they came out of the creek bed, being much weathered, and containing a very large quantity of water; therefore, the coal from a depth should not contain nearly as much.

"The coal-bearing series here consist of sandstone, grits, and clay beds (the latter of which are often micaceous) the whole being overlaid by a bed of ferruginous conglomerate, containing large water-worn pebbles of quartzite, quartz, and other metamorphic rocks. This bed is not met with in many places in the district, and probably forms the junction between the coal-bearing series and the crystalline rocks."

KIMBERLEY.

According to the researches of Mr. Woodward—

"It is also highly probable that coal will be found in the Northern portion of the Kimberley district, near Wyndham, where

the carboniferous series is largely developed in the quartzite and sandstone-capped flat-topped hills, with shale beds beneath, attaining an elevation of as much as 1,000 feet. These shale beds must be of great thickness, for in the well at the base of the Bastion Hill they were found to go down over 100 feet, whilst they are seen in sections in the side of the hill 700 or 800 feet. The only way to make certain whether coal beds do exist is by boring, which at the same time would probably secure a water supply for the town."

A bore was put down at the foot of Bastion Hill in 1897 to a depth of 690 feet, in the search of artesian water. The bore passed through* a series of hard sandstones and shales, but met with no coal seams. As the bore had not pierced the whole thickness of sedimentary strata, it cannot be said that the question of coal has been definitely settled.

BROWN COALS OF THE SOUTH COAST.

"Along the bold rough South coast, between Albany and Point D'Entrecasteaux, without shelter or harbours for even small vessels, stretches a narrow strip of calcareous country covered with abundance of herbage. This coast consists of bold headlands of granite or high cliffs of sandstone, which latter, when it forms capes, is always protected to a certain extent from the action of the sea by reefs or islands of rock. There are numerous inlets along this coast, but these are useless as harbours, since they are either too shallow or have their mouths barred, whilst they are gradually being filled up with mud by the running streams which discharge themselves into them. These inlets were at no very remote period permanently connected with the sea by wide and deep channels, but since the coast rose, the sand dunes which now form the cliffs were blown up, fringing the coast between the inlets and the sea, often completely blocking up their entrances.

"The only good harbour upon this coast is King George's Sound, where the natural features have protected its entrance from being closed up by sand. The inner, or Princess Royal Harbour, is, however, being rapidly filled in at its head by a sand drift, which is gradually creeping over the coastal hills. When this line of coast hills was first formed they were more continuous than they are now, but at the sametime they were lower, whilst behind them was a low swampy flat or lagoon into which the streams from the North discharged themselves. In this lagoon accumulated large quantities of vegetable matter which gradually formed a peaty substance of the brown coal class. This coal is found to be of better quality in the middle of these basins, whilst towards the edges it consists almost entirely of sand; it is also overlaid by black sand which contains a very large quantity of vegetable matter."†

* Report of the Department of Public Works for the Year 1897-98, Perth: By Authority: 1898.

† H. P. Woodward, Mining Handbook to the Colony of Western Australia: 2nd Edition. Perth; By Authority: 1895; pp. 145-146.

The same author pointed out, in a report upon the prospect of obtaining coal near Albany,* that a large basin surrounded by granite exists in the neighbourhood, but that boring operations alone could determine the presence of coal seams. For the purpose of testing this basin a bore was put down on the Eastwood Estate, $7\frac{1}{2}$ miles from Albany, on the Great Southern Railway Line.

The following is a section of the strata pierced:—

Nature of Strata.	Thickness.	Depth.
	ft. in.	ft. in.
Sandy Peat	8 6	...
Ferruginous Sandstone	1 0	8 6
Sand and Black Clay	5 6	9 6
Quicksand	5 0	15 0
Ferruginous Sandstone	0 1	20 0
Quicksand	30 0	20 1
Stiff Black Clay	4 0	50 1
Quicksand...	10 0	54 1
Brown Coal and Quicksand ...	3 0	64 1
Total	67 1	67 1

The bore collapsed at 67 feet, without the whole thickness of the beds having been obtained.

An analysis of the seam showed its composition to be—

Water	6·275
Volatile Matter	18·84
Fixed Carbon	14·835
Ash	60·05

Mr. Woodward reports†:—"The sample is of a dull sooty black colour, showing a good deal of vegetable structure. It is not highly mineralised, but fairly compact, soft, friable, and soils the hands. The fracture is irregular, showing a laminated structure. It does not ignite readily, but when made red hot it burns slowly, giving out a good deal of heat, and when ignited in a tube it gives off a small quantity of gas, tar, and water. The percentage of water is low for a coal of this class; the volatile matter, consisting of luminous and non-luminous gases, is also low, so is the fixed carbon, whilst the quantity of ash is enormous. The coke was in the form of a fine sooty powder, whilst the ash was light and of a creamy colour."

In 1899 further boring operations in the vicinity of Albany have been carried out, but so far without any great success.

A further reference is made by Mr. Woodward to the deposits of the South Coast, and a description given of the mode of occur-

* General Report for the Year 1892 etc. Perth: By Authority: 1893; pp. 3-4.
† *Loc. cit.*

rence and origin of lacustrine coals, which this author remarks occur:—

"In seams often of considerable size, with underlying shale beds, which latter contain roots and pieces of wood, with pyrites more or less decomposed, when it forms red ironstone nodules and alum shale, this latter being met with as efflorescences on the cliff faces. Above these coal beds are sandstone, often containing large quantities of carbonaceous matter, whilst the coal itself varies greatly in quality, often consisting largely of sand. There are no indications of true coal upon this coast; in fact, the granite basins seem to be filled entirely with these recent lacustrine and estuarine deposits. . . . These ancient basins are generally small, but even where large ones occur, as to the Northward of Albany, there are no indications which would lead one to hold out the least hope that true coal will ever be found here, because brown coal associated with sandstone, shale, and pyrites are no indication that the carboniferous formation exists, since these same rocks occur in many different modern formations."

GRAPHITE.

Graphite has been found in association with certain ferruginous deposits in the Champion Bay District, but proved to contain too large a percentage of iron to be of any remarkable value.

A deposit of graphite was worked in the neighbourhood of Kendenup; the graphite proved to be of fair quality, but the distance from market proved an insuperable bar to its economic working.

"Some years ago a deposit of graphite (plumbago) was discovered near the head of the Donnelly River, about 10 miles East of Dickson's, on the Lower Blackwood Road, and between eight and ten miles South of Nelson Grange, the property of Mr. Allnut, a few miles from Bridgetown. About six years ago a syndicate was formed at the Vasse, which took up and prospected several blocks, but the price of graphite at the time was so low that the work was abandoned before much had been done. Early in the year 1894 Mr. Knox Brown reported that he had discovered apparently payable plumbago on a protection area which he had taken up near the older find. This latest discovery is situated between two creeks which flow in deep valleys, from one of which a drive to the North has been put in to the side of the ridge, at right angles to the outcrop of the deposit, with the result that three beds were passed through. The first of these which outcrops near the mouth of the drive is 28 feet in thickness, being followed by 13 feet of schistose rock, containing a small bed 1 foot 6 inches in thickness, whilst the third bed is 8 feet in thickness. Several other shafts have been sunk, and open cuttings made to test the run of these beds. From one of the former, about four chains to the Westward of the drive, which appears to be upon the large bed, a sample, weighing 25cwt., was sent to England in order to ascer-

tain its commercial value. In another shaft, about 15 chains further up the spur to the Westward, at an elevation of about 100 feet above the mouth of the drive, the deposit was again struck at a few feet from the surface. These beds should, correctly speaking, be called plumbaginous schists, since the percentage of graphite contained is so small, the main portion of the deposit consisting of a magnesian silicate. The formation consists principally of micaceous and talcose schists, which here strike East and West, dipping at a high angle to the Northwards; whilst following along to the Southward, close to the outcrop of the graphite beds, is a large dyke of intrusive granite. A little to the Eastward of the drive, at the junction of the two creeks, the outcrop of this deposit is lost, but beds of steatite are met with along this line as far as Wilgarup; therefore the graphite seams will also probably be found to extend in this direction, the local break in the continuity of the rocks being due in all probability to a fault. To the Westward the graphite can be traced for several miles, but the beds seem to split up and become smaller upon the claims that were first prospected. This deposit of earthy graphite is due to the alteration of poor shaley coal seams, the metamorphosis being in all probability due to the indurated granite to the Southward which changed the coal seams into graphite and the shale into schists. It offers exceptional facilities for cheap working, since the spur upon which it is situated rises so rapidly that a drive following the strike from the outcrop in the creek would have 100 feet of backs in a distance of about 20 chains; whilst if crosscuts were driven about five chains from the valley which runs parallel to the strike the seam would be obtained. The firm of crucible makers to whom the sample was sent reported it to be of no commercial value, but since graphite is put to a multitude of uses at the present day, in most of which forms it is largely adulterated with earthy matter, and so long as our deposit does not contain any deleterious substance, it should certainly be of some value. When we consider the large size of the deposit, the cheapness with which it could be worked, its short distance from good roads, the enormous quantity of karri timber on the spot of almost any length, and the perpetual supply of running water, it should certainly, if not at present, prove in the near future to be of great value." *

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*Woodward, H. P. The South-Western portion of the Colony. Appendix 1. Report of the Department of Mines for the Year 1894. Perth; By Authority: 1895; p. 9.

CHAPTER X.

GUANO DEPOSITS.

General — Houtman's Abrolhos Islands — Analyses of Western Australian Guano—Production of Western Australian Guano.

While perhaps the accumulations of guano occurring in the Abrolhos Islands and elsewhere in the North, formed as they are by organic agencies, may not in a strictly scientific sense be mineral deposits, their economic importance is a sufficient justification for referring to them in a description of the mineral resources of the Colony.

That the importance of these deposits is considerable may be judged from the appended table of Statistics, showing the production of guano in the Colony, as prepared from official data. No record would appear to have been kept of the quantity of guano raised previous to the year 1847, also during the years 1847 to 1855, 1855 to 1865, 1865 to 1872, 1872 to 1876, and also the years between 1879 and 1882. From the official figures it appears that since 1847, 81,978 tons of guano have been raised, and that the total royalty paid to the Government from that date amounted to £38,861. From the year 1847, as shown by the Customs figures, 76,766 tons of guano, valued at £313,323, have been exported from the Colony.

Up to the present time the chief source of the guano raised is in Houtman's Abrolhos Islands, West of the town of Geraldton.

"Houtman's Rocks or Houtman's Abrolhos consists of a little archipelago, for the most part of coral formation, situated between latitudes 28° 15′ and 29° South, some 30 miles off the mainland coast of Western Australia and immediately opposite Champion Bay and the thriving port of Geraldton. More closely examined the Abrolhos Archipelago is found to be separable into four secondary groups, characterised in order from North to South, as the North Island, Wallaby, Easter, and Pelsart Groups. With the exception of the Wallaby Group, which contains plutonic rocks corresponding in character with those of the mainland, and having an elevation of some 30 or 40 feet, the larger residue is entirely of coral formation, while reefs of considerable extent also encircle the Wallaby Series. Their composition, as manifested more particularly in the islets of the Easter and Pelsart Groups, consists of hard coral limestone conglomerate, undermined and weathered on its exposed aspects into low overhanging cliffs and promontories often of the most fantastic shape, which frequently show embedded in their eroded surfaces but slightly altered Corolla of the Madreporidæ of which they are principally composed. . . . . . From time immemorial, as testified to by the deep guano deposits, Houtman's Abrolhos has been the home or breeding centre of countless hosts of sea birds, which still resort thither in enormous quantities in the breeding season. . . . . . On account of the vast accumulations of guano resulting from the sea-birds having so long made the

Abrolhos their headquarters, this island group possesses a considerable commercial value."*

In August, 1897, Mr. Licensed Surveyor Wells was despatched from Geraldton to the Abrolhos Islands for the purpose of officially estimating the quantity of guano still available on the Group. † This officer visited 10 islands of the Eastern group, and on four of them, viz., Rat, Third Beacon, and Wooded Islands found guano deposits varying from 4 inches to 27 inches in thickness. The islands of the Eastern Group are estimated to contain 13,944 tons of guano. Of the 14 islands of the Pelsart Group examined, nine were found to contain guano deposits, viz., Pelsart, Gun Island, and seven small islands adjacent. The deposits varied from 7 inches to 13 inches in thickness; the group is supposed to contain 48,468 tons of guano. Mr. Wells examined 18 islands of the Wallaby Group, but only made surveys of four, viz., West Wallaby, Pelican Island, and North and South Pigeon Islands. These were estimated to contain 38,088 tons of guano varying in thickness from 4 inches to 17 inches. Small quantities of guano occur in several of the lesser islands.

Twenty-three analyses of the Abrolhos Guano have been made and are given in the table annexed.

Analyses of Abrolhos Guano.

No.	Sand.		Moisture.		Phosphates.	
	A.	B.	A.	B.	A.	B.
1	7·14	10·63	4·13	5·36	55·01	55·51
2	6·04	5·86	6·65	7·33	50 54	49·23
3	8·20	8·10	4·32	5·73	58·09	55·23
4	0·80	0·63	5·45	7·76	67·98	66·15
5	0·79	0·96	7·23	8·36	60·88	59·71
6	0·80	1·56	4·07	5·73	69·40	67·13
7	3·36	2·70	5·12	6·86	68·28	63·50
8	0·93	0·96	6·28	7·66	68·84	64·83
9	1·71	0·46	6·72	9·23	62·67	67·13
10	0·72	1·46	6·56	9·60	73·17	58·17
11	2·08	1·85	4·00	5·01	77·40	72·14
12	0·41	0·50	9·37	7·63	69·26	65·71
13	0·36	0·43	6·80	7·93	69·68	65·60
14	0·85	0·30	8·61	10·06	51·38	46·50
15	0·48	0·56	8·16	11·23	55·43	51·73
16	0·26	0·23	6·37	8·06	54·73	51·95
17	1·40	1·40	5·40	6·56	66·46	62·17
18	0·16	0·15	7·56	16·03	61·72	56·65
19	3·96	3·63	7·01	9·60	48·31	46·28
20	6·04	4·73	8·90	11·60	53·90	50·20
21	0·64	1·01	4·37	2·53	63·53	61·12
22	13·83	13·30	4·72	3·56	64·51	51·94
23	4·81	4·63	3·74	2·90	69·82	64·07
Mean	2·86	2·87	6·15	7·66	62·65	58·81

A. Analyst.—S. S. Dougall, Perth, Western Australia.
B. Analyst.—John Hughes, London, England.

* Saville-Kent, W. The Naturalist in Australia. London, 1897; pp. 135-137.

† A. J. Wells. Report on the Abrolhos Islands Guano Deposits. Perth By Authority: 1897.

The Production of Guano in Western Australia.

Year.	Guano Raised.								Guano Exported.				
	Quantity.		Total Value.		Total Royalty Paid.				Quantity.		Total Value.		
	tons	cwt.	£ s. d.		£	s.	d.		tons	cwt.	£	s.	d.
1847	*		*		*				3	0	18	0	0
1855	*		*		*				25	0	125	0	0
1865	*		*		*				35	0	175	0	0
1872	*		*		*				52	0	107	0	0
1876	2534	0	...		1267	0	0		735	0	367	10	0
1877	14355	0	...		7177	10	0		1212	0	6060	0	0
1878	19865	3	...		9932	11	6		13219	0	66095	0	0
1879	*		*		*				12041	0	54184	0	0
1880	*		*		*				1330	0	6650	0	0
1881	*		*		*				*Nil*				
1882	*		*		*				*Nil*				
1883	724	0	...		362	0	0		456	0	2964	0	0
1884	2505	0	...		2012	5	11		1163	0	7559	10	0
1885	973	0	...		311	11	4		528	0	3432	0	0
1886	2631	0	...		1654	3	0		10157	10	66023	15	0
1887	3360	0	...		2052	14	0		3158	0	20527	0	0
1888	3582	0	...		1433	12	0		3110	0	12440	0	0
1889	3583	0	...		1697	10	0		3395	0	8488	0	0
1890	4038	0	...		1956	10	0		3913	0	9783	0	0
1891	6225	0	...		2858	10	0		6251	0	15628	0	0
1892	2569	0	...		1355	13	4		2508	0	4384	0	0
1893	3297	0	...		1570	0	0		4030	0	7052	0	0
1894	2001	0	...		969	10	0		2239	0	3919	0	0
1895	1945	0	...		544	0	0		100	0	200	0	0
1896	1618	0	...		191	5	0		1660	0	4506	0	0
1897	2569	0	...		331	6	0		1496	5	3250	0	0
1898	3604	0	...		1278	14	11		3950	0	9386	0	0
1899	2092	4	...		743	5	1		2045	10	5165	0	0
Totals	84070	7	...		39699	12	1		78812	5	318488	15	0

* No records.

CHAPTER XI.

ARTESIAN WATER.

Artesian Wells, Records of Bores, Analyses of Artesian Water.

In its broader topographical features, Western Australia falls naturally into three geographical divisions:—

(*a.*) The Coastal Plain. This consists in reality of a fringe of strata around the coast, with a more or less gentle slope to the seaward. The plain is formed for the most part of shallow water deposits, sandstones, conglomerates, and thin shales, with occasionally incoherent sand and clays. The Plain has a width of 60 or 70 miles in places on the Western Coast, though in the country at the head of the Great Australian Bight, the Plain, absolutely devoid of rivers, extends some 200 miles into the interior. The inner margin of the Coastal Plain reaches an altitude of 600 feet above sea-level in certain localities. The Coastal Plain is separated from the interior by a belt of

(*b.*) Hill Ranges, which form what may be called the escarpment of the Plateaus and Plains of the Interior. The Hill Ranges have an average elevation of about 1,200 feet, though isolated Ranges reach altitudes of 4,000 feet above sea-level. This escarpment has either a short or steep slope down to the edge of the Coastal Plain, into which it gradually merges. This belt of country, drained by the rivers of the Colony, is formed of granitic and metamorphic rocks, the decay of which produces excellent soil; it comprises, owing to its rainfall, the principal Agricultural Districts of the Colony.

(*c.*) The Plateaus and Plains of the Interior consist of a broken tableland, from which rise isolated hills and ridges of metamorphic rocks, often separated by sand-plains of some considerable extent, and containing depressions occupied by saline marshes, clay flats, brine lakes or deposits of salt. There are no rivers, and the rainfall is slight. This plateau forms the chief mineral region of the Colony.

The Coastal Plain is of considerable economic importance, in that the certainty of obtaining artesian water from the underlying strata has now been thoroughly established. The system of boring for artesian water, however, is capable of great expansion in the Colony, and is limited only by locality.

A glance at any Geological Map of Western Australia shows an enormous extent of Recent and Tertiary Strata entering the Colony at its Eastern border, in the Nullabor Plains, and extending without any interruption as far as Israelite Bay. These strata consist of porous limestones associated with beds, into which the rainfall is rapidly absorbed and discharged seawards in the form of fresh water springs. Where these strata have been pierced on the South Australian side of the border, the section invariably shows from 300ft. to 500ft. of sandy water-bearing beds, of undetermined age, covered by a variable thickness of calcareous strata of both Older and Newer Tertiary age. The beds have a prevailing dip towards the Great Australian Bight, and water rises in the bore holes to a height equal to that of the sea level. So far, however, the water obtained has proved to be either salt or brackish, but at any rate suitable for stock purposes.

The whole of the area of these beds in the Southern portion of this Colony may be described as an artesian water area, though there may be, and undoubtedly are, conditions affecting the water supply, such as local variations in the thickness, the relative porosity of the beds, and the unevenness of the floor upon which they were laid down, which, with our present meagre knowledge, can only be set at rest by the operations of the drill.

The strata of the Coastal Plain in the vicinity of the Swan River have proved that in certain areas they possess all the conditions necessary for yielding an overflowing supply of water. The structure of the Coastal Plain differs in some respects from the typical areas in which artesian water has been obtained in the Eastern portions of Australia. The strata are horizontal or nearly so, though occasionally there is a slight local dip of about five degrees in places. The effect of this horizontality is shown in the fact that the water-carrying beds do not crop out on the surface at the foot of the Darling Range, but impinge directly against that portion which is now concealed from view. These beds, clays (marls ?), and sandstones with occasional limestones, do not maintain an uniform thickness throughout, but are disposed in the form of lenticular beds, some of which appear to be of exceptionally absorbtive properties.

The bores which have already been put down between the Darling Range and the Coast have shown how irregular are the strata from which the water has been obtained, and what is of further moment, they also demonstrate that only in one instance has the base of the water-carrying beds been reached.

The first supply of artesian water in the vicinity of Perth, was obtained some time during the year 1873, in a bore put down in the

search for coal, under the advice of Mr. H. Y. L. Brown, then Government Geologist. The situation of the bore was somewhere near the Canning River, a few miles South-East of Perth, and close to the foot of the Darling Range. The following is a description of the material brought up from time to time, as determined by Mr. Brown:—

Canning River Bore.

Nature of Strata.	Thickness.	Depth.	Remarks.
	ft. in.	ft. in.	
Sand, gravel, sandy clay, and small boulders of igneous rocks, clay containing pyrites	16 0	...	"The sand and gravel in the above list, with the exception of that near the surface, must be considered mostly as coming from beds of sandstone and conglomerate which have been worked up by the action of the boring tools. In the same way the black and blue clay, when *in situ*, existed as shale. It is more than probable again that the rounded fragments brought up from certain depths had previously fallen down from a higher position."* Artesian water is still flowing from this bore.
Rounded granite pebbles, and gravel, grit, blue clay and shale containing carbonised matter	25 0	16 0	
Gravel, sand, and pieces of quartz and granite: black clay with pyrites	23 0	41 0	
Rounded quartz, granite, grit, quartzite, and black clay with pyrites	29 0	64 0	
Rounded pieces of granite, and igneous rocks, gravel, sand, quartz, etc., with fragments of lignite	33 0	93 0	
Rounded fragments of igneous rocks, sand, etc.; yellow sandstone at 139 feet: coarse grit and sand at 171 feet	45 0	126 0	
Total	171 0	171 0	

In the year 1885, Mr. E. T. Hardman, of Her Majesty's Geological Survey of Ireland, who at that time acted as Government Geologist, dealt fully with the question of supplying the city of Perth with artesian water, and after dealing with the principles of the construction of artesian wells, concluded that it would be hopeless to expect an overflowing supply of water anywhere in the neighbourhood. This conclusion is the only one which could be legitimately arrived at so long as it was assumed that the water-carrying strata must be arranged in the form of one of those ideal basins, sections of which have done duty for many years in geological manuals. Recent observations have shown that this condition rarely obtains in Nature, and that in all the important artesian areas, the porous beds are so arranged that there is only one side of a synclinal trough present, and the water has abundant facilities for escape at a much lower level than that at which it is received.

So far, in this Colony, what may be called a true artesian basin is on the Collie River, where a copious supply of water is at

* H. Y. L. Brown: On a geological exploration to the N.E. of Champion Bay, Western Australia. Perth: By Authority, 1871; pp. 10-11.

present flowing from Bores Nos. 2 and 3, put down with the object of testing the coal measures; details in connection with these can be seen by a reference to Chapter IX., above. From observations which have been made it would seem that the amount of water flowing from the bores on the Collie River increases and diminishes in a manner which points to dependence upon seasonable variations.

All the available information about artesian wells has been collected and tabulated for convenience of reference. So far, as official data show, there are 16 artesian wells in the Colony, reaching an aggregate depth of 14,165 feet, yielding a total flow of 4,806,504 gallons per diem, which is equivalent to 1,754,373,960 gallons per annum. In addition to these there are three sub-artesian wells, of an aggregate depth of 2,511 feet, from which 531,700 gallons of water can be pumped daily, or 194,070,500 gallons per annum.

The Pound (near the Railway Station, Perth).

Nature of Strata.	Thickness.		Depth.		Remarks.
	ft.	in.	ft.	in.	
Clay	38	0	...		
Coarse sandstone	27	0	38	0	
Clay	18	0	65	0	
Dark grey sandstone	18	0	83	0	
Clay	9	0	101	0	
Soft sandy marl	110	0	110	0	
Total	220	0	220	0	

West Perth Railway Station.

Nature of Strata.	Thickness.		Depth.		Remarks.
	ft.	in.	ft.	in.	
Drift sand	36	0	...		Altitude of bore, 37·71 feet above sea level. Yields 500,000 gallons per diem. Hydrostatic head, 77·71 feet above sea level; and 40 feet above surface. Hydrostatic pressure, 17·32lbs. per square inch.
Clay	14	0	36	0	
Drift sand (incoherent sandstone)	9	0	50	0	
Clay	4	0	59	0	
Coarse drift (incoherent sandstone)	25	0	63	0	
Sandstone and clay	20	0	88	0	
Sandstone (with thin bands of shale)	718	0	108	0	
Total	826	0	826	0	

Subiaco Bore.

Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.	Remarks.
Sand...	40	0	...		Altitude of bore, 117·15 feet above sea level. This bore was started from bottom of shaft, which is 103 feet deep. Sub-artesian water obtained; water rose in the bore to within 45 feet of natural surface. At 52 feet below the surface the overflow into the shaft is 161,000 gallons per diem. At 67 feet 10 inches below the surface the overflow into the shaft is 450,000 gallons per diem. Static head, 72 feet above sea level.
Sandstone with hard bands ...	63	0	40	0	
Sand and boulders	67	0	103	0	
Conglomerate (very hard) ...	10	0	170	0	
Soft sandstone	178	0	180	0	
Clayey and sandy shales ...	210	0	358	0	
Drift sand (incoherent sandstone)	98	0	568	0	
Clayey shale	60	0	666	0	
Soft sandstone	150	0	726	0	
Total	876	0	876	0	

Perth Racecourse Bore.

Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.	Remarks.
Sandy clay	29	0	...		Altitude of bore, 40 feet above sea level. Yields 536,000 gallons per diem. Hydrostatic head 58·69 feet above sea level, and 18·69 feet above surface. Hydrostatic pressure, 8lbs. per square inch.
Yellow sand	11	0	29	0	
Stiff clay	4	0	40	0	
Sandstone	264	0	44	0	
Sandy shale with bands of sandstone	154	0	304	0	
Sandstone	309	0	458	0	
Sandstone with bands of clay shale	332	7	767	0	
Total	1,099	7	1,099	7	

Leederville Bore.

Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.	Remarks.
Sand (incoherent sandstone) with three bands	130	0	...		Yield, 288,000 gallons per diem. Pressure in lbs. per square inch 4·75. Static head above surface in feet 11·33. Surface of ground above sea level 58·85 feet. Depth of principal water-bearing strata, 1,023 feet.
Calcareous sandstone	23	0	130	0	
Limestone	5	6	153	0	
Calcareous sandstone	47	6	158	6	
Shell marl	691	6	206	0	
Sandstone	8	6	897	6	
Calcareous shales with one band of calcareous sandstone ...	103	4	906	0	
Calcareous sandstone with two bands of sandstone	104	11	1,009	4	
Total	1,113	3	1,113	3	

South Perth Bore.

Nature of Strata.	Thickness.		Depth.		Remarks.
	ft.	in.	ft.	in.	
Sand (incoherent sandstone ?) ...	75	0	...		Output, 372,384 gallons per diem. Pressure in lbs. per square inch 44·5. Static head above surface in feet 102·75. Surface of ground above sea level 18·01 feet. Depth of principal water-bearing strata, 1,837 feet.
Calcareous shale	142	0	75	0	
Sand (incoherent sandstone ?) ...	263	0	217	0	
Calcareous shales with five (5) hard bands	1,351	0	480	0	
Sand (incoherent sandstone) ...	29	6	1,831	0	
Total	1,860	6	1,860	6	

Melville Water Park Estate Bore.

Nature of Strata.	Thickness.		Depth.		Remarks.
	ft.	in.	ft.	in.	
White sand	31	0	...		Altitude of bore, 9·44 feet above sea level. Yields 140,000 gallons per diem. Hydrostatic head, 49 feet above sea level; and 39·56 above surface. Hydrostatic pressure, 17lbs. per square inch. Temperature of water, 91° Fahrenheit.
Sands and clays	184	0	31	0	
Sandy calcareous shales with fossils	78	0	215	0	
Sandstone	15	0	293	0	
Sandy shale	59	6	308	0	
Sandstone	77	6	367	6	
Sandy shale, with occasional calcareous bands	947	6	445	0	
Drift sand and shale, with nodules of pyrites and quartz boulders	16	0	1,392	6	
Sandstone and grit	78	6	1,408	0	
Granite	3	6	1,486	6	
Total	1,490	0	1,490	0	

Water Hall Estate Bore, Guildford (J. Morrison).

Nature of Strata.	Thickness.		Depth.		Remarks.
	ft.	in.	ft.	in.	
Dark soil	3	0	...		Altitude of bore, 35·02 feet above sea level. Yields 200,000 gallons per diem. Hydrostatic head, 46 feet above sea level, and 10·98 feet above surface. Hydrostatic pressure, 4·75lbs. per square inch.
Clay, gravel, and cement ...	47	0	3	0	
Clay	77	0	51	0	
Sandstone (drift sand)	105	0	128	0	
Clay shale	30	0	233	0	
Sandstone with band of shale ...	126	0	263	0	
Clay shale	67	0	389	0	
Alternations of sandstone and clay shale	235	0	456	0	
Total	691	0	691	0	

Bebo Moro Bore, Guildford (H. E. B. Gull).

Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.	Remarks.
Clay	6	0	...		Altitude of bore, 19·46 feet above sea level. Yields 80,000 gallons per diem. Hydrostatic head, 37 feet above sea level, and 17·54 feet above surface. Hydrostatic pressure, 7·50 lbs. per square inch.
Sand and clay	62	0	6	0	
Sandstone	96	0	68	0	
Clay	101	0	163	0	
Loam and sand	7	0	264	0	
Black clay	39	0	271	0	
White sand (? incoherent sandstone)	8	0	310	0	
Black clay	33	0	318	0	
Clay and loam	5	0	351	0	
Drift sand (? incoherent sandstone)	52	0	356	0	
Ironstone gravel	...		...		
Total	408	0	408	0	

Woodbridge Estate Bore, Guildford (C. Harper).

Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.	Remarks.
Dark loam	10	0	...		Altitude of bore, 14·30 feet above sea level. Yields 150,000 gallons per diem. Hydrostatic head, 33 feet above sea level, and 18·30 feet above surface. Hydrostatic pressure, 7·92 lbs. per square inch.
Drift sand (? incoherent sandstone)	59	0	10	0	
Clay and loam	60	0	69	0	
Drift sand (? incoherent sandstone)	18	0	129	0	
Clay and loam	12	0	147	0	
Drift sand	76	0	170	0	
Total	235	0	235	0	

Municipal Bore at Guildford.

Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.	Remarks.
Blue and yellow clays and gravel	34	0	...		Altitude of bore, 11·37 feet above sea level. Yields 1,120,000 gallons per diem. Hydrostatic head, 64·55 feet above sea level, and 53·18 feet above the surface. Hydrostatic pressure, 23lb. per square inch.
Sand...	6	0	34	0	
Black clays	10	0	40	0	
Sand and water-worn pebbles ...	25	2	50	0	
Black sandy clay	147	7	75	2	
Sand and sandstones impregnated with pyrites	792	3	222	9	
Sand with layers of shale ...	187	0	1,015	0	
Total	1,202	0	1,202	0	

Lockeridge Estate Bore, Guildford (H. Hamersley).

Nature of Strata.	Thickness.		Depth.		Remarks.
	ft.	in.	ft.	in.	
Surface *débris*	1	6	...		Altitude, 14·29 feet above sea level. Yields 123,000 gallons per diem. Hydrostatic head, 21 feet above sea level, and 7 feet above surface. Hydrostatic pressure, 3·03lbs. per square inch.
Clay and sandstone bands ...	13	6	1	6	
Drift sand (? incoherent sandstone)	25	0	15	0	
Clay (? shale)	16	0	40	0	
Sand (? incoherent sandstone) ...	27	6	56	0	
Decomposed ironstone	2	0	83	6	
Dark clay shales with coal veins	146	0	85	6	
Sand (? incoherent sandstone) ...	7	6	231	6	
Clay shale	12	0	239	0	
Drift sand (? incoherent sandstone)	10	0	251	0	
Clay shale	14	0	261	0	
Drift sand (? incoherent sandstone)	28	0	275	0	
Clay shale	16	0	303	0	
Drift sand (? incoherent sandstone)	50	0	319	0	
Sandstone (with three thin bands of clay shale)	304	0	369	0	
Clay shale	32	0	673	0	
Sand (? incoherent sandstone) ...	8	0	705	0	
Clay shale	23	0	713	0	
Sand (? incoherent sandstone, with bands of clay shale)	62	0	736	0	
Total	798	0	798	0	

Midland Junction Bore.

Nature of Strata.	Thickness.		Depth.		Remarks.
	ft.	in.	ft.	in.	
Sand and clay ...	21	0	...		Altitude of bore, 13 feet above sea level. Between 60 feet and 71 feet, 5,000 gallons of water per diem rose to 4 feet above the surface. Between 98 feet and 107 feet, 8,900 gallons per diem rose to 5 feet above the surface. Between 166 feet and 246 feet, water at the rate of 129,600 gallons per diem overflowed with a hydrostatic head of 12 feet. Between 262 feet and 350 feet water at the rate of 151,000 gallons per diem overflowed with a hydrostatic head of 18·7 feet. Between 363 feet 6 inches and 419 feet, water at the rate of 100,000 gallons per diem overflowed with a hydrostatic head of 18·7 feet. The water-bearing beds, which are being drawn upon for the Midland Junction supply, are those between 262 feet and 350 feet, and 363 feet and 420 feet. All the others are shut off. Hydrostatic pressure, 8·66lbs. per square inch.
Sandstone	86	0	21	0	
Sandy shale ...	59	0	107	0	
Grey sandstone ...	80	0	166	0	
Arenaceous clay shale	16	0	246	0	
Grit and clay shale	88	0	262	0	
Clay shale ...	13	0	350	0	
Sandstone and clay shale	56	0	363	6	
Clay shale ...	81	0	419	0	
Total ...	500	0	500	0	

Several bores have been put down in the neighbourhood of Bunbury, and artesian water obtained at comparatively shallow depths. Southwards from Point Casuarina, and to the West of

the town, is a narrow fringe of columnar basalt rising from beneath the sea level, but forming no conspicuous elevation. Basalt is, however, known at Black Point, and at one or two places on the mainland between that place and the town of Bunbury. To the basalt succeeds a long irregular line of sand dunes, upon the highest point of which, Marlston Hill, the light-house is placed. By far the larger portion of Bunbury, however, is built upon an extensive alluvial flat, whose surface is raised but little above the high-water mark.

Bore No. 1, situate at the Eastern end of Stephen Street, and about half-a-mile West of the outcrop of the basaltic lava, was carried down to a depth of 30ft. The drill entered the basalt after passing through 10ft. of superficial deposits, and was carried down through it for a further distance of 20ft., when operations ceased, there being some doubts as to whether the rock was disposed in the form of a bed or beds. The section in bore at the Bunbury Brewery, below Marlston Hill, proves that the basalt is in the form of beds, but boring operations have not been carried deep enough to show whether the clay beneath the lava is merely a thin bed dividing two individual lava flows, or is the old floor upon which the basalt was laid down.

The following are the particulars in connection with the strata pierced in these bores, together with other cognate points:—

Bunbury Bore No. 1.

Nature of Strata.	Thickness.		Depth.		Remarks.
	ft.	in.	ft.	in.	
Superficial deposits	10	0	...		Bore abandoned. No water.
Basaltic Lava	20	0	10	0	
Total	30	0	30	0	

Bunbury Bore No. 2.

Nature of Strata.	Thickness.		Depth.		Remarks.
	ft.	in.	ft.	in.	
Surface clay	2	0	...		Altitude of bore, 2 feet above sea level. At a depth of 97 feet a sub-artesian supply, capable of yielding 70,000 gallons per diem was encountered.
Black clay	7	0	2	0	
Sand	2	4	9	0	
Cement	0	3	11	4	
Coarse sand	5	5	11	7	
Yellow clay	2	0	17	1	
Sand	5	0	19	0	
Hard yellow clay	2	6	24	0	
Coarse white sand	5	0	26	6	
Cemented sand	0	3	31	6	
Stiff dark clay	3	9	31	9	
Coarse sand and gravel	21	9	35	6	
Cemented sand	3	0	57	3	
Sand	5	0	57	6	
Yellow clay	5	0	62	6	
Sand	36	6	67	6	
Total	104	0	104	0	

Bunbury Bore No. 3.

Nature of Strata.	Thickness.	Depth.	Remarks.
	ft. in.	ft. in.	
Clay	10 0	...	Altitude of bore, 2 feet above sea level. The sandstone at 86 feet yielded an overflowing supply of 10,000 gallons per diem. The principal supply is drawn from the sand at the bottom of the well. The total yield is 100,000 gallons per diem. Hydrostatic head untested.
Yellow sand	14 0	10 0	
Ironstone conglomerate	0 10	24 0	
Hard clay	4 0	24 10	
Sand and cement	2 0	28 10	
Soft sandstone	2 0	30 10	
Clay (shale ?)	5 0	32 10	
Sandstone	8 0	37 10	
Clay (shale ?)	8 0	45 10	
Sandstone	13 0	53 10	
Clay (shale ?)	4 0	66 10	
Sandstone	23 0	70 10	
Yellow clay (shale ?)	6 0	93 10	
Coarse sand (incoherent sandstone)	18 0	99 10	
Hard yellow clay (shale ?) ...	16 0	117 10	
Coarse sand (incoherent sandstone)	17 0	133 10	
Yellow clay (shale ?)	5 0	150 10	
Coarse sand (incoherent sandstone)	25 0	155 10	
Sandstone	68 0	180 10	
Gravel (conglomerate ?)	2 0	248 10	
Soft yellow clay (shale ?) ...	2 0	250 10	
Drift sand (incoherent sandstone)	23 0	252 10	
Gravel (conglomerate)	1 0	275 10	
Blue pipeclay (shale ?)	32 0	276 10	
Drift sand (incoherent sandstone ?)	71 0	308 10	
Pipeclay (shale ?)	0 6	379 10	
Drift sand (incoherent sandstone)	36 6	380 10	
Total	416 8	416 8	

Bunbury Brewery Bore.

Nature of Strata.	Thickness.	Depth.	Remarks.
	ft. in.	ft. in.	
Sand and surface *débris*	12 0	...	The bore was commenced at the foot of a well, and a depth of 112 feet from the surface attained. The water, which rises to about the top of the basalt at a depth of 12 feet from the surface, is of excellent quality, and is said to be well suited for brewing purposes.
Basalt	97 0	12 0	
Clay	3 0	109 0	
Total	112 0	112 0	

The beds of the Coastal Plain further to the North, in the neighbourhood of Geraldton, have been explored by means of bores. Three bores have been put down, two at Geraldton, and one at Dongara, near the mouth of the Moore River.

The country in the vicinity of Geraldton is composed of sandy limestones, very little disturbed from the position in which they were originally laid down. The calcareous strata are in places covered with deposits of blown sand. To the East of Geraldton the limestones rest upon the old crystalline rocks, which are absolutely impervious to water below the zone of decomposition. Owing to the horizontality of the strata the basal beds of the Coastal Limestone series do not crop out anywhere near the junction of the limestone and the older rocks, but merely abut against the underground continuation thereof. Horizontal tablelands of grit and conglomerate, resting on granite and gneissic rock, form conspicuous landmarks in the neighbourhood. Some of the tablelands rise to considerable elevations above the level of the surrounding country. Many of the grits are sufficiently open and porous to be capable of absorbing and transmitting water were they disposed in such a way as to admit of this.

A bore was put down in the station yard at Geraldton, and operations were continued to a depth of 420 feet, when the old granitic floor was reached. The strata pierced, as can be seen by the following section, were shales and sandstones of the ordinary type: none of the beds yielded a supply of artesian water.

Geraldton Station Yard Bore.

Nature of Strata.	Thickness.		Depth.		Remarks.
	ft.	in.	ft.	in.	
Sand	24	0	...		Altitude, approximately, 10 feet above sea level. No water.
Conglomerate	42	0	24	0	
Soft sandstone	10	0	66	0	
Conglomerate	15	0	76	0	
Sandstone	10	0	91	0	
Shale	3	0	101	0	
Sandstone and shale	25	0	104	0	
Conglomerate	0	4	129	0	...
Coal	0	10	129	4	
Sandstone	4	0	130	2	
Clay with coal veins	3	6	134	2	
Coarse white sand with boulders	23	0	137	8	
Clay with coal veins	0	10	160	8	
Clay	5	0	161	6	
Pyrites [?]	2	1	166	6	
Grey shale	29	0	168	7	
Sandstone with coal veins ...	9	0	197	7	
Sandstone [soft]	20	0	206	7	
White clay	12	0	226	7	
Pyrites [?] and boulders	2	0	238	7	
Sandstones and pyrites	5	0	240	7	
Sandstone	6	0	245	7	
Clay	25	0	251	7	
Sandstone and shale	42	0	276	7	
White clay	5	0	318	7	
Clay with sandstone and pyrites [?], in bands	32	0	323	7	
Clay	17	0	355	7	
Blue shale	45	0	372	7	
Granite	2	6	417	7	
Total	420	1	420	1	

The scene of boring operations was eventually shifted to the Racecourse at Geraldton, and a depth of 1,153 feet obtained. The section herewith shows the nature of the strata pierced, and also proves the existence, hitherto unsuspected, of a subterranean granitic ridge, which, on carefully weighing all the evidence, seems to trend generally North and South. The following are the particulars in connection with the strata pierced:—

Geraldton Racecourse Bore.

Nature of Strata.	Thickness of strata. ft.	in.	Depth from surface. ft.	in.	Remarks.
Clays	5	0	...		Altitude of bore, 82 feet above sea level. A pumping supply of 11,700 gallons of very salt water met with at a depth of 72·9 feet. The water rose to a height of 45 feet below the surface.
Red and yellow sands	29	0	5	0	
Red clay	2	0	34	0	
Gravel	0	6	36	0	
Blue and red clays	7	6	36	6	
Red gravel with fragments of decomposed limestone ...	5	0	44	0	
Sand...	4	0	49	0	
Blue clays	12	0	53	0	
Sand with small bands of clay and pyrites intermixed ...	72	0	65	0	
Drift sand (incoherent sandstone)	13	6	137	0	
Ferruginous conglomerate ...	3	6	150	6	
Sandstone	12	0	154	0	
Clay...	1	0	166	0	
Sandstone	19	0	167	0	
Shell limestone	21	0	186	0	
Sandstone	4	0	207	0	
Shell limestone	5	0	211	0	
Blue clay	5	0	216	0	
Shell limestone	3	0	221	0	
Sandstone	3	0	224	0	
Loose sand [incoherent sandstone] with bands of shale intermixed	4	0	227	0	
Shell limestone	2	0	231	0	
Conglomerate	6	0	233	0	
Sandstone with bands of shell, shale, and pyrites	57	0	239	0	
Conglomerate containing petrified wood	1	0	296	0	
Sandstone containing bands of shale and pyrites	39	0	297	0	
Sandstone [incoherent sandstone?] with coal-seams intermixed	8	0	336	0	
Sandstone containing bands of shale	13	0	344	0	
Conglomerate	12	0	357	0	
Dark shale	5	0	369	0	
Coal seam	0	6	374	0	
Dark shale	3	0	374	6	
Conglomerate	1	6	377	6	
Shale with bands of coal intermixed	14	0	379	0	
Argillaceous sandstone with bands of pyrites	7	0	393	0	
Limestone with bands of grey shale	20	0	400	0	

Geraldton Racecourse Bore—continued.

Nature of Strata.	Thickness of strata. ft.	in.	Depth from surface. ft.	in.	Remarks.
Dark shale	10	0	420	0	
Limestone with bands of light grey shale	16	0	430	0	
Shale with fragments of coral limestone	3	0	446	0	
Limestone	6	0	449	0	
Dark shale with bands of sandstone	32	0	455	0	
Shale	3	0	487	0	
Sand [incoherent sandstone ?] ...	40	0	490	0	
Conglomerate	2	0	530	0	
Sand [incoherent sandstone ?] ...	9	0	532	0	
Conglomerate	9	0	541	0	
Shale	2	0	550	0	
Conglomerate with bands of pyrites	43	0	552	0	
Sand [incoherent sandstone ?] ...	10	0	595	0	
Fine silt	13	0	605	0	
Conglomerate	10	0	618	0	
Sandstone	12	0	628	0	
Argillaceous limestone	45	0	640	0	
Conglomerate and bands of pyrites	12	0	685	0	
Sandstone [incoherent sandstone]	4	0	697	0	
Argillaceous limestone	14	0	701	0	
Sand [incoherent sandstone ?] ...	10	0	715	0	
Argillaceous limestone	5	0	725	0	
Hard grey sandstone	3	0	730	0	
Red shale	2	0	733	0	
Sandstone, with bands of shale...	5	6	735	0	
Red shale	3	6	740	6	
Sandstone with bands of shale and conglomerate intermixed...	219	0	744	0	
Shale	4	0	963	0	
Sandstone	15	0	967	0	
Shale	2	0	782	0	
Hard grey sandstone with bands of shale	27	0	984	0	
Red shale	12	0	1,011	0	
Sandstone with thin bands of shale	44	0	1,023	0	
Red shale	9	0	1,067	0	
Sandstone and shale	4	0	1,076	0	
Conglomerate	11	0	1,080	0	
Sandstone with bands of shale and pyrites	76	0	1,091	0	
Shale	17	0	1,167	0	
Sandstones and thin shales ...	75	0	1,184	0	
Conglomerate	10	0	1,259	0	
Alternations of sandstone and shale	177	0	1,269	0	
Calcareous shale and agillaceous limestone	28	0	1,446	0	
Sandstone	52	6	1,474	0	
Siliceous crystalline limstone ...	0	9	1,526	6	
Coarse sandstone	4	3	1,527	3	
Total	1,531	6	1,531	6	

The whole country along the coast from Geraldton to Dongara is made up of the Coastal Limestone series, which rise in the form of sand plains to an altitude of about 500ft. These beds effectually conceal the underlying rocks, and at the few places where these are seen a low dip to the West is observable. From Geraldton the Coastal Limestone series widens out and covers an extensive area of country, which attains its maximum width on the Irwin River.

A Government bore was put down, near the mouth of the Irwin River at Dongara, to a depth of 2,111ft. Particulars in connection with this are given in Chapter IX.

A bore was put down at Onslow to a depth of about 1,729 feet, but it was not very successful, hence its abandonment. The particulars in connection with this bore are as follows:—

Onslow Bore.

Nature of Strata.	Thickness. ft.	Thickness. in.	Depth. ft.	Depth. in.	Remarks.
Sand	30	0	...		Water struck at 1,015 feet, which trickled over the surface at the rate of 20 to 30 gallons per diem. At 1,717 feet yields 120 gallons per diem. Hydrostatic pressure, 10·82lbs. per square inch. Hydrostatic head, 25 feet above surface. Water salt.
Limestone	183	10	30	0	
Calcareous shale	30	11	213	10	
Grey shale	361	8	244	9	
Grey dolomite	34	10	606	5	
Grey shale	731	3	641	3	
Dark grey marl	82	6	1,372	6	
Sandstone	0	10	1,455	0	
Clay (? shale)	21	2	1,455	10	
Dark grey marl	66	0	1,477	0	
Clay (? shale)	3	1	1,543	0	
"Hard stone" (?)...	0	8	1,546	1	
Sandstone	9	6	1,546	9	
"Hard rock" (?)	0	3	1,556	3	
Shale	6	2	1,556	6	
Calcareous shale	5	4	1,562	8	
Shale	70	8	1,568	0	
Black argillaceous limestone ...	0	4	1,638	8	
Shell marl	53	1	1,639	0	
Shale	4	0	1,692	1	
Black argillaceous limestone ...	2	0	1,696	1	
Shale	14	5	1,698	1	
Clay and sand	8	6	1,712	6	
Basalt	2	0	1,721	0	
Marl	5	10	1,723	0	
Total	1,728	10	1,728	10	

In addition to the above, numerous shallow bores have been put down in the Eastern Agricultural Districts. The wells put down have derived their supplies from those superficial deposits which are surcharged with water, and which cover an extensive area of country. The supply yielded by these wells is directly dependent upon the saturation of the ground immediately surrounding them, and is in no sense artesian. Full details in connection with these wells have already been published,* and need not be further referred to.

* A. Gibb Maitland. Proposed boring for artesian water in the Eastern Agricultural Districts. Annual Progress Report of the Geological Survey for the Year 1898. Perth: By Authority, 1899; pp. 22-29.

The following table gives the analyses of water from certain of the artesian wells of the Colony. These were made for the sole purpose of determining the suitability of the waters for domestic use, and are in many particulars incomplete from a mineral point of view :—

*Chemical Analyses of Water from Artesian Wells.**

Analyst: E. A. MANN.

No. of Analysis.	Locality of Bore.	GRAINS PER GALLON.											GRAINS PER 100,000.				
		Total Solids.	Alumina and Iron.	Carbonates.		Chlorides.		Total Chlorine.	Sulphates.		Reaction.	Degree of Hardness.	Ammonia.		Oxygen absorbed.		Nitrogen Nitrates.
				Calcium. $Ca\,CO_3$	Magnesium $Mg\,CO_3$	Sodium. NaCl	Magnesium $Mg\,Cl_2$		Calcium. $Ca\,SO_4$	Magnesium $Mg\,SO_4$			Free.	Albuminoid.	In 15′	In 4 hours.	
1	Geraldton Station Yard ...	12·77	...	9·8	1·2	907·2	173·1	122·5	61·9	...	...	...	...	...	...	...	1·3
2	Dongara	...	...	...	...	1008·5	...	607 6	...	...	...	...	...	...	...	...	...
3	Do.	...	...	...	...	602·43	...	365·1	...	...	...	...	...	...	...	...	...
4	Water Hall Estate... ...	51·24	...	...	...	...	...	...	...	...	...	7°	·005	·003	·047	·063	...
5	Municipal Bore, Guildford	36·12	...	...	...	14·5	...	...	...	...	...	7°	·007	·007	...	...	...
6	Do. do. ...	93·6	1·55	5·95	...	73·88	...	...	888·5	...	Alk.	11·5°	·014	·003	·01	...	·014
7	Do. do. ...	87·22	...	...	...	...	...	39·2	...	...	...	12°	·0145	0085	...	...	...
8	Perth Cricket Asn. Ground	...	...	...	...	...	...	...	...	...	...	...	·02	·001	...	·043	·024
9	Leederville Asn. Ground ...	39·9	...	...	...	...	...	19·4	...	...	...	3°	·017	·001	...	·07	·033
10	Perth Station Yard ...	34·72	...	...	...	...	...	15·12	...	...	...	7·5°	·04	·011	...	...	...
11	Do.	44·34	°/o ·896	8·568	...	32·67	...	...	2·198	...	...	...	·02	·0015	...	·019	·027
12	Do.	...	...	...	...	...	...	...	...	...	...	...	·015	·002	...	...	...
13	Subiaco	...	...	...	...	...	...	...	...	...	...	...	·06	·046	...	·27	...
14	Perth, Wellington St. Bore	...	...	...	...	...	...	...	...	...	...	...	·013	·008	...	...	...
15	Do. do. ...	...	...	...	...	...	...	...	...	...	...	...	·018	·006	...	...	...
16	Do. do. ...	34·27	2·06	6·244	...	23·436	...	...	2·268	...	...	...	·0185	·0025	...	·015	·059
17	South Perth	16·1	...	...	...	...	...	6·02	...	...	...	2·5°	...	...	...	...	...
18	Do.	66·08	...	...	...	...	...	30·1	...	...	...	4°	·03	·002	...	·061	·02
19	Melville Water Park Estate	...	...	...	...	...	...	...	...	...	...	...	·062	·005	...	...	...
20	Collie Bore (? 2 or 3) ...	16·1	...	...	...	...	...	...	...	...	...	...	·009	·0125	·0132	·0132	...
21	Do. ,, ,, ...	21·07	...	...	...	...	...	...	...	...	...	...	·0125	·011	·012	·0512	...
22	Do. ,, ,, ...	12·04	...	...	...	...	...	...	...	...	...	...	·0135	·0155	·012	·01807	...
23	Do. ,, ,, ...	20·44	...	...	...	...	...	...	...	...	...	...	·0285	·0125	·015	·0361	...
24	Bunbury (2) Bore	21·42	8·19	3·587	...	21·162	...	...	...	1·18	...	...	...	...	...	...	...

* Annual Report of the Department of Public Works for the Year 1898-99. Perth: By Authority, 1899; p. 52.

CHAPTER XII.

CENSUS OF MINERALS OF WESTERN AUSTRALIA.

By E. S. Simpson, B.E., F.C.S., Mineralogist and Assayer.

The following list of minerals has been compiled from the various reports and other documents in the library of the Geological Survey at Perth, as well as from personal observation. Such a small area of the Colony has up to the present been examined systematically from a geological standpoint, that the census is necessarily very incomplete, but it will illustrate the wide distribution of useful minerals in Western Australia, and form the basis for a more complete catalogue as fresh discoveries are chronicled.

The commoner rock-forming minerals such as quartz, felspars, micas, amphibole, etc., have been omitted, except where their occurrence is of marked interest.

Most of the localities mentioned in this list are to be found on the 60-Mile map (dated 1/12/97) published by the Mines Department. In order that they may be the more readily identified the goldfield or division of the Colony in which they are situated is always indicated, the following abbreviations being employed :—

K.—Kimberley G.F
Pil.—Pilbarra G.F.
W.P.—West Pilbarra G.F.
Ash.—Ashburton G.F.
Gas.—Gascoyne G.F.
P.H.—Peak Hill G.F.
M.—Murchison G.F.
Yal.—Yalgoo G.F.
E.M.—East Murchison G.F.
M.M.—Mount Margaret G.F.
N.C.—North Coolgardie G.F.
Ygn.—Yilgarn G.F.
C.—Coolgardie G.F.
B.A.—Broad Arrow G.F.
E.C.—East Coolgardie G.F.
N.E.C.—North-East Coolgardie G.F.
Dun.—Dundas G.F.

Localities Outside Goldfields.

N.E. —East of 121° East and North of 28° South.
N.W.—West of 121° East and North of 28° South.
S.W.—West of 121° East and South of 28° South.
S.E. —East of 121° East and South of 28° South.

Amalgam (*Alloy of gold and mercury*).—Boulder, E.C.

Anglesite (*Sulphate of lead*).—Gorge Creek, Ash.

Aragonite (*Carbonate of calcium*).—Kanowna, N.E.C.

Arsenopyrite (*Sulpharsenide of iron*).—Ruby Creek, K.; Niagara, N.C.; Smithfield, B.A.; Coolgardie, C.; Paddington, B.A.

Asbestos (*Hydrated silicate of magnesium*).—Jarman Island, W.P.; Tambourah (70 miles N. of), Pil.; Menzies, N.C.; Hannan's Lake, E.C.; Mt. Magnet, M.; Upper Henry River, N.W.; Feysville, E.C.

Asbolite (*Hydrous oxide of manganese and cobalt*).—Kanowna, N.E.C. Norseman, Dun.

Atacamite (*Hydrated oxychloride of copper*).—Peninsula, Dun.

Azurite (*Hydrated carbonate of copper*).—Yalgoo, Yal.; Sir Samuel, E.M.; Northampton, S.W.; Arrino, S.W.; Mt. Misery, S.W.; Ravensthorpe Ranges, S.W.; Coolgardie, C.; Kurawa, B.A.; Narra Tarra, S.W.; Whim Creek, W.P.; Leonora, M.M.

Barite (*Sulphate of barium*).—Northampton, S.W.; Denmark, S.W.

Bismite (*Oxide of bismuth*).—Yalgoo, Yal.

Bismuth (*Native metal*).—Burbanks, C.; Lawlers, E.M.; Dundas, Dun.

Bismuthinite (*Sulphide of bismuth*).—Yalgoo, Yal.

Bismutite (*Hydrated carbonate of bismuth*).—Lawlers, E.M.; Burbanks, C.

Bitumen (*Oxygenated mixture of hydro-carbons*).—Horseshoe, P.H.

Blende (*Sulphide of zinc*).—Northampton, S.W.; Geraldine, N.W.; Coolgardie, C.; Lawlers, E.M.; Yandicoogina, Pil.; Cardup, S.W.

Bornite (*Sulphide of copper and iron*).—Wyman's, Pil.; Gabanintha, M.

Bournonite (*Sulphantimonite of copper and lead*).—Wiluna, E.M.; Boulder, E.C.

Breunerite (*Carbonate of magnesium and iron*).—Bardoc, B.A.; Hannan's Lake, E.C.

Calaverite (*Telluride of gold*).—Boulder, E.C.

Calcite (*Carbonate of Calcium*).—Hall's Creek, K.; Mary River, K.; Panton River, K.; Coolgardie, C.; Boulder, E.C.; Hannan's Lake, E.C.; Paddington, B.A.; Napier Range, K.; Oscar Range, K.; Geikie Range, K.; Mt. Pierre, K.; Devil's Pass, K.; Fremantle, S.W.; and elsewhere along the West Coast; Red Hill, C.; Moore River, S.W.; Hill River, S.W.; Quindalup, S.W.; etc.

Cassiterite (*Oxide of tin*).—Head of the Bow River, K.; Head of the Lennard River, N.E.; Western Shaw, Pil.; Brockman's Soak, Pil.; Greenbushes, S.W.

Cerargyrite (*Chloride of silver*).—Red Hill, C.

Cerussite (*Carbonate of lead*).—Mt. DeCourcy (10 miles S.E. of), N.W.; Gorge Creek, Ash.; Geraldine, N.W.; Northampton, S.W.; Roebourne, W.P.

Chalcosite (*Sulphide of copper.*)—Northampton, S.W.

Chalcopyrite (*Sulphide of copper and iron*).—Hall's Creek, K.; Panton River, K.; Ruby Creek, K.; Tambourah, Pil.; Wyman's Pil.; Yandicoogina, Pil.; 20-Mile, Sandy Creek, Pil.; Whim Creek, W.P.; Croydon, W.P.; Hong-kong, W.P.; Roebourne, W.P.; Red Hill, N.W.; Wongan Hills, S.W.; Northampton, S.W.; Geraldine, N.W.; Coolgardie, C.; Sir Samuel, E.M.; Earlstoun, M.M.; Knutsford, Ygn.

Chrysocolla (*Hydrated silicate of copper*).—Red Hill, N.W.; Mt. Misery, S.W.; Sir Samuel, E.M.; Ravensthorpe Ranges, S.W.

Coal.—Collie, S.W.; Fly Brook, S.W.; Upper Irwin River, S.W.; Dongara, S.W.; Dardanup, S.W.; Coolgardie, C.

Coloradoite (*Telluride of mercury*).—Boulder, E.C.

Copper (*Native metal*).—Mount Scratch, S.W.; Roebourne, W.P.; Geraldine, N.W.; Northampton, S.W.; Sir Samuel, E.M.; Coolgardie, C.

Covellite (*Sulphide of copper*).—Northampton, S.W.; Arrow Lake, B.A.; Kanowna, N.E.C.; Whim Creek, W.P.

Crocoisite (*Chromate of lead*).—Menzies, N.C.

Cuprite (*Oxide of copper*).—Whim Creek, W.P.; Tambourah, Pil.; Red Hill, N.W.; Geraldine, N.W.; Northampton, S.W.; Mount Misery, S.W.

Cyanite (*Silicate of aluminium*).—Londonderry, C.

Diamond (*Carbon*).—Nullagine, Pil.

Dolomite (*Carbonate of calcium and magnesium*).—Onslow, N.W.; Coolgardie, C.; Kanowna, N.E.C.; Hannan's Lake, E.C.; Millie Soak, M.

Epidote (*Silicate of calcium, aluminium, and iron*).—Mary River, K.; Ramsay Range, near Margaret River, K.; Broad Arrow, B.A.; Mundaring, S.W.; Donnybrook, S.W.; Southern Cross, Ygn.

Epsomite (*Hydrous sulphate of magnesium*).—Lake, eight miles North of Kanowna, N.E.C.; and most other salt lakes of the Southern interior.

Galena (*Sulphide of lead*).—Hall's Creek, K.; Mt. Dockerell, K.; Tambourah, Pil.; Warrawoona, Pil.; Hardey River, Ash.; Gorge Creek, Ash: Mt. Edith, N.W.; Mt. DeCourcy, N.W.; Horseshoe, P.H.; Geraldine, N.W.; Northampton, S.W.; Oakagee, S.W.; Narra Tarra, S.W.; Earlstoun, M.M.; Cardup, S.W.; Nannine, M.; Southern Cross, Ygn.; Menzies, N.C.; Coolgardie, C.; Broekman's, K.; Panton River, K.; Ruby Creek, K.; Roebourne, W.P.

Garnet (*Almandine, Silicate of Iron, and Aluminium*).—Upper Lennard River, K.; Albany, S.W.; Northampton, S.W.; Donnybrook, S.W.; Greenbushes, S.W.

Gold (*Native metal*)—

A.—Kimberley G.F.:—Hall's Creek, Broekman's, Mt. Doekerell, Ruby Creek, Panton River, Mt. Coghlan, Mt. Bradley.

B.—Pilbarra G.F.:—Marble Bar, Nullagine, Elsie Creek, Cooke's Creek, Mosquito Creek, Shark's Gully, Yandicoogina, Sandy Creek, Warrawoona, Bamboo Creek, Talga Talga, Tambourah, Shaw River, Head of Turner River.

C.—West Pilbarra G.F.:—Egina, Hong Kong, Pilbarra, Mallina, Towranna, Croydon, Roebourne, Nichol, Lower Nichol.

D.—Ashburton G.F.:—Gorge Creek, Top Camp, Mt. Mortimer, Hardey River, Tannaradgie, Dead Finish, Soldier's Seeret.

E.—Gascoyne G.F.:—Bangemall, El Dorado.

F.—Peak Hill G.F.:—Peak Hill, Horseshoe, Mt. Maitland.

G.—Murchison G.F.:—Cue, Day Dawn, Mainland, Island Lake Austin, Gabanintha, Burnakura, Nannine, Meekatharra, Abbott's, Garden Gully, Munara, Mt. Magnet, Cuddingwarra, Boogardie, Lennonville, Weld Range, Quin's, Tuckanarra, Webb's, Mulleta.

H.—East Murchison G.F.:—Lawlers, Sir Samuel, Wiluna, Barlow's, Abbott's, Darlôt, Ogilvie's, Kathleen Valley, Anderson's, Wilson's.

I.—Mt. Margaret G.F.:—Mt. Margaret, Leonora, Randwick, Westralia Mt. Morgan, Euro, Golden Hill, Jubilee, Lancefield, Murrin Murrin, Laverton, Earlstoun, Mt. Weld, Korong, Redeastle Benalla, Mt. Ross, Kurrajong, Mt. Davis, Crawford, Mt. Vardon, Bates, Mt. Amy, Hawk's Nest, Stirling, King of the Hills, Mt. George, Pride of the North, Mertondale, Australian Peer, Malcolm, Mt. Malcolm, Cardinia, Mt. Abednego, Waverley.

J.—Yalgoo G.F.:—Yalgoo, Bilberatha, Noongal, Pinyalling, Lang's, Bates, Gullewa, Ederga, Carlaminda, Cumberland, Woodley's, Rothesay, Mt. Singleton, Nancarrong, Wadgingarra, Mugga Mugga.

K.—North Coolgardie G.F.:—Menzies, Goongarrie, Niagara, Griffithston, Mt. Ida, Mulline, Ularring, Yerilla, Mt. Catherine, Pendennie, Eucalyptus, Yilgangi, Edjudina, Linden, Pennyweight Point, Pyke's Hollow, Tampa, Armidale, Callion, Mt. Remarkable.

L.—Yilgarn G. F.:—Mt. Jackson, Knutsford, Southern Cross, Parker's Range, Jacolettis, Yellowdine, Hope's Hill.

M.—Coolgardie G.F.:—Coolgardie, Burbanks, Londonderry, Bullabulling, Gibralta, Gnarlbine, Red Hill, Widgiemooltha, Bonnievale, Kundanna, Barwon, Kunanalling, Kintore, London, Dunn's, Dunnsville, Carbine, Balgarrie, Grant's, Mascotte, Cashman's, Carnage, Christmas Reef, Siberia.

N.—Broad Arrow G.F.:—Bardoc, Broad Arrow, Paddington, Windanya, Black Flag, Dixie.

O.—East Coolgardie G.F.:—Kalgoorlie, Boulder, Feysville, Block 45, Binduli, Boorara, Block 48, Block 50.

P.—North-East Coolgardie G.F.:—Kanowna, Kurnalpi, Bulong, Ballagundi, Mt. Monger, Taurus, Garribaldi, Wellington, Vosperton, Lindsay's, Mulgarrie, Mt. Eba.

Q.—Dundas G.F.:—Dundas, Norseman, Peninsula, Mt. Kirk, Mt. Deans, Buldania.

R.—Donnybrook G.F.:—Donnybrook.

S.—Localities outside Proclaimed Goldfields:—Ravensthorpe Ranges, S.W.; Greenbushes, S.W.; Blackboy Hill, S.W.; Peterwangy, S.W ; Wongan Hills, S.W.; Kendinup, S.W.; Bindoon, S.W.

Graphite (*Carbon*).—Cue, M.; Northampton, S.W.; Kendinup, S.W.; Head of Donnelly River, S.W.; Coolgardie, C.; Kalgoorlie, E.C.; York, S.W.

Guano (*Mixture of Phosphates of Calcium with Carbonates, etc.*).—Abrolhos Islands, S.W.; Lacepede Islands, N.W.; Monte Bello Islands, N.W.

Gypsum (*Hydrated sulphate of calcium*).—Lake Cowan, Dun.; Lake, eight miles North of Kanowna, N.E.C.; most other salt lakes in the Southern interior; Coolgardie, C.; Upper Irwin River, S.W.; Oscar Range, K.; Onslow, N.W.; Kalgoorlie, E.C.; Island Lake Austin, M.; Menzies, N.C.

Hematite (*Oxide of iron*).—Mt. Hardman, K.; Mt. Marmion, K.; Marble Bar, Pil.; Mt. Hale, P.H.; Peak Hill, P.H.; Mt. Gould, P.H.; Mount No Name, P.H.; Weld Ranges, M.; Montagu Range, E.M.; Mt. Narryer, N.W.; Goomalling, S.W.; Greenhills, S.W.; Cookernup, S.W.; Munara, M.; Mt. Jackson, Ygn.; Boulder, E.C.; Bardoc, B.A.; Mulgarrie, N.E.C.; Bridgetown, S.W.; Red Hill, N.W.

Halite (*Common salt, chloride of sodium*).—All the salt lakes in the Southern interior; Rottnest Island, S.W.

Halloysite (*Hydrated silicate of aluminium*).—Cue, M.

Hausmannite (*Oxide of manganese*).—Broad Arrow, B.A.

Hypersthene (*Silicate of iron and magnesium*).—Margaret River, K.; Greenhills, S.W.; Bardoc, B.A.

Ilmenite (*Oxide of iron and titanium*).—In all the more basic igneous rocks of the Colony, as well as in most river sands. Largely developed at Greenbushes, S.W.; Mt. Barker, S.W.; Fitzroy River, K.

Iron (*Native metal*).—Meteorites consisting largely of metallic iron have been found at Wogerlin Spring, Youndegin District, S.W.: Mooranopin, S.W.; Hammersley Range, N.W.; Ballinoo, M.

Jamesonite (*Sulphantimonite of lead*).—Mt. DeCourcy, N.W.

Kalgoorlite (*Telluride of gold, silver, and mercury*).—Boulder, E.C.

Kaolin (*Hydrated silicate of aluminium*).—Very pure at Menzies, N.C.; Kanowna, N.E.C.; Collie, S.W.; and elsewhere.

Lepidolite (*Fluosilicate of aluminium, potassium, and lithium*).—Londonderry, C.

Limonite (*Hydrated oxide of iron*).—Found everywhere throughout the Colony. Some more important localities are:—Rough Range, K.; East of Mt. Elder Range, K.; Poondanah, Pil.; Gibson's Desert, N.E.; Peak Hill, P.H.; Clackline, S.W.; Greenhills, S.W.; Greenbushes, S.W.; Coolgardie, C.; Kalgoorlie, E.C.; Bardoc, B.A.; etc.

Lollingite (*Arsenide of iron*).—Coolgardie, C.; Boulder, E.C.

Magnesite (*Carbonate of magnesium*).—Coolgardie, C.; Hannan's Lake, E.C.; Kanowna, N.E.C.; Bardoc, B.A.; Menzies, N.C.

Magnetite (*Oxide of iron*).—Lodestone Hill, K.; Paradise, S.W.; Collie River, S.W.; Darling Ranges, near Pinjarrah, S.W.; Katanning, S.W.

Malachite (*Hydrated carbonate of copper*).—Devil's Pass, N.E.; Oscar Range, near Brooking Creek, N.E.; Geikie Range, N.E.; Mt. Pierre N.E.; Mueller Range, near Margaret River, K.; Hall's Creek, K.; Panton River, K.; Whim Creek, W.P.; Tambourah, Pil.; Wyman's, Pil.; Red Hill, N.W.; Roebourne, W.P.; Gorge Creek, Ash.; Horseshoe, P.H.; Mt. Gould, P.H.; Geraldine, N.W.: Yalgoo, Yal.; Northampton, S.W.; Arrino, S.W.; Mt. Misery, S.W.; Wongan Hills, S.W.; Boorara, E.C.; Coolgardie, C.; Broad Arrow, B.A.; Sir Samuel, E.M.; Mulline, N.C.; Narra Tarra, S.W.; Phillip's River, near East Mt. Barren, S.W.; Middle Mt. Barren, S.W.; Leonora, M.M.; Goongarrie, N.C.

Molybdenite (*Sulphide of molybdenum*).—Clackline, S.W.; Coolgardie, C.; Southern Cross, Ygn.; Buldania, Dun.

Molybdite (*Oxide of molybdenum*).—Clackline, S.W.

Muscovite (*Silicate of aluminium and potash*).—Occurs in most granites and metamorphic rocks throughout the Colony. Developed on a large scale at Tambourah, Pil.; Londonderry, C.; Wagin, S.W.; Northampton, S.W.; Mullayup, S.W.; Pyramid Hill, N.W.

Opal (*Hydrous silica*).—1. Common opal.—Mooran, P.H.; Hannan's Lake, E.C.; Jerramungup, S.W. 2. Hyalite.—Coolgardie, C.; Bardoc, B.A.; Mt. Magnet, M. 3. Siliceous sinter.—Northampton, S.W.; Molygoa Well, P.H.; Bubba Ngundi Creek, M.; Burbanks, C.; Hannan's Lake, E.C.

Orthoclase (*Silicate of aluminium and potassium*).—Occurs in the granites, etc., throughout the Colony. In large crystals at Northampton, S.W.; Albany. S.W.; Collie Quarry, S.W.; Londonderry, C.

Psilomelane (*Hydrated oxide of manganese*).—Coolgardie, C.

Pyrites (*Sulphide of iron*).—Occurs plentifully in almost every district in the Colony.

Pyrolusite (*Oxide of manganese*).—Mt. Hardman, K.; El Dorado, Gas.; Tooncoonarlagee, Pil.; Wiluna, E.M.; York, S.W.

Pyromorphite (*Chlorophosphate of lead*).—Narra Tarra, S.W.; Northampton, S.W.; Geraldine, N.W.

Pyrrhotite (*Sulphide of iron*).—Southern Cross, Ygn.; Coolgardie, C.; Burbanks, C.; Knutsford, Ygn.; Moora, S.W.

Quartz (*Silica*).—1. Ordinary quartz.—Occurs in every district of the Colony as a constituent of rocks or veins. Good crystals are found at Burbanks, C.; Mulgarrie, N.E.C. 2. Chalcedony.—Widely distributed amongst the older rocks in the form of jasper "bars," as at Coongan River, Pil.; Weld Ranges, M.; Hannan's Lake, E.C. Important localities for other varieties of chalcedony are Lubbock Range, K.; Mt. Elder Range, K.; Tooncoonarlagee, Pil.; Hannan's Lake, E.C.; Londonderry, C.

Roscoelite (*Silicate of aluminium, vanadium, etc.*).—Boulder, E.C.

Scheelite (*Tungstate of calcium*).—Southern Cross, Ygn.; Coolgardie, C.

Serpentine (*Hydrated silicate of magnesium*).—Occurs in many districts as a product of decomposition of amphibolites and other basic rocks. Important localities are Mount Dick, S.W.; Coolgardie, C.; Hannan's Lake, E.C.; *vide* "Asbestos."

Siderite (*Carbonate of iron*).—Cue, M.; Menzies, N.C.; Kanowna, N.E.C.; Kalgoorlie, E.C.; Hannan's Lake, E.C.; Vosperton, N.E.C.; Burbanks, C.

Silver (*Native metal*).—Nannine, M.

Sphene (*Titano-silicate of calcium*).—Coolgardie, C.

Stibiotantalite (*Tantalo-niobate of antimony*).—Greenbushes, S.W.

Stibnite (*Sulphide of antimony*).—Mallina, W.P.; Peewah, W.P.

Sulphur (*Native element*).—Peak Hill, P.H.

Sylvanite (*Telluride of gold and silver*).—Boulder, E.C. (Teste, Frenzel, Min. Petr. Mitth., 17, 288, 1897).

Talc (*Hydrated silicate of magnesium*).—Lennonville, M.; Coolgardie, C.; Cue, M.

Tenorite (*Oxide of copper*).—Croydon, W.P.; Hong Kong, W.P.; Red Hill, N.W.; Arrino, S.W.

Tin (*Native metal*).—Greenbushes, S.W.

Tourmaline (*Silicate of boron, aluminium, etc.*).—Lennard River at junction with Richenda River, K.; Mt. Phillip, K.; Brockman's Soak, Pil.; Northampton, S.W.; Bowes, S.W.; Greenbushes, S.W.; Niagara, N.C.; Pinyalling, Yal.; Widgiemooltha, C.; Kalgoorlie, E.C.

Turgite (*Hydrated oxide of iron*).—Greenbushes, W.A.

Vanadinite (*Chlorovanadate of lead.*)—Pinyalling, Yal.; Coolgardie, C.

Wolfram (*Tungstate of iron*).—Roebourne, W.P.

Zircon (*Silicate of zirconium*).—Greenbushes, S.W.

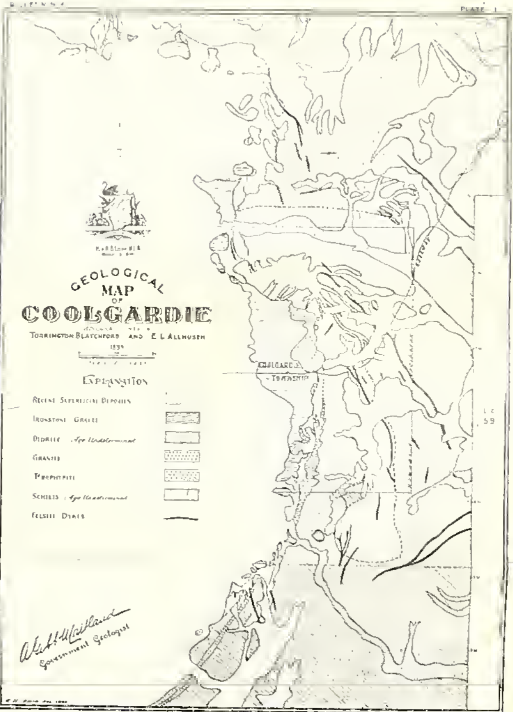
Appendix A.

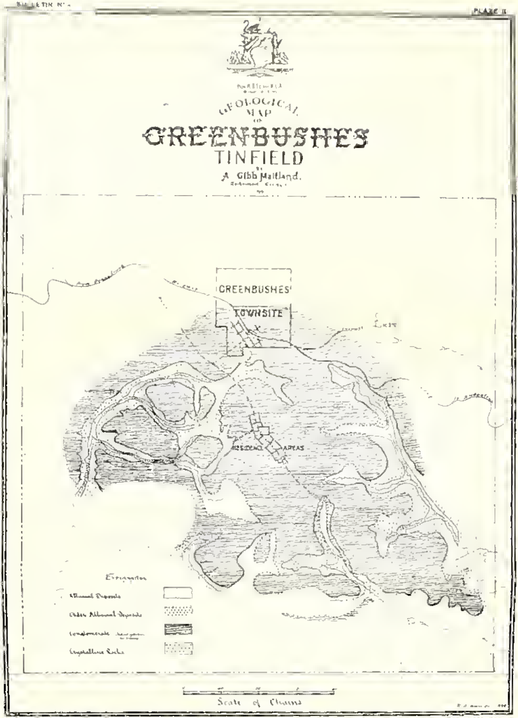
General Return showing the Value of the Mineral Products of the Colony up to the end of 1899.

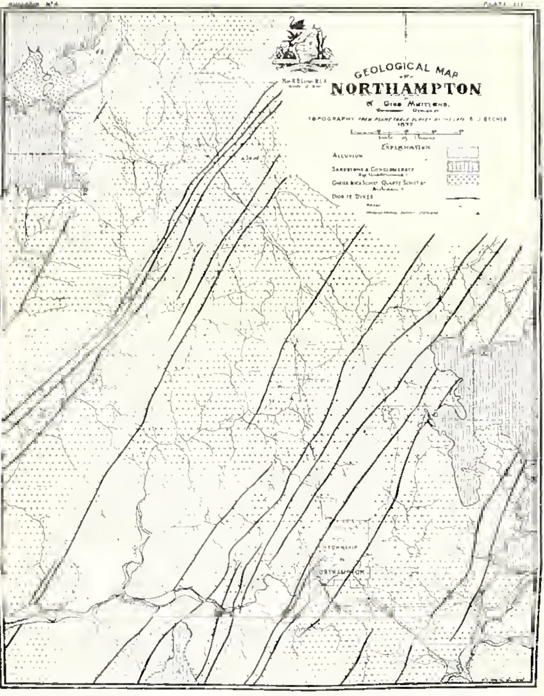
The aggregate value of the mineral products of the Colony up to the close of 1899 is estimated to be £17,490,446, made up as follows:—

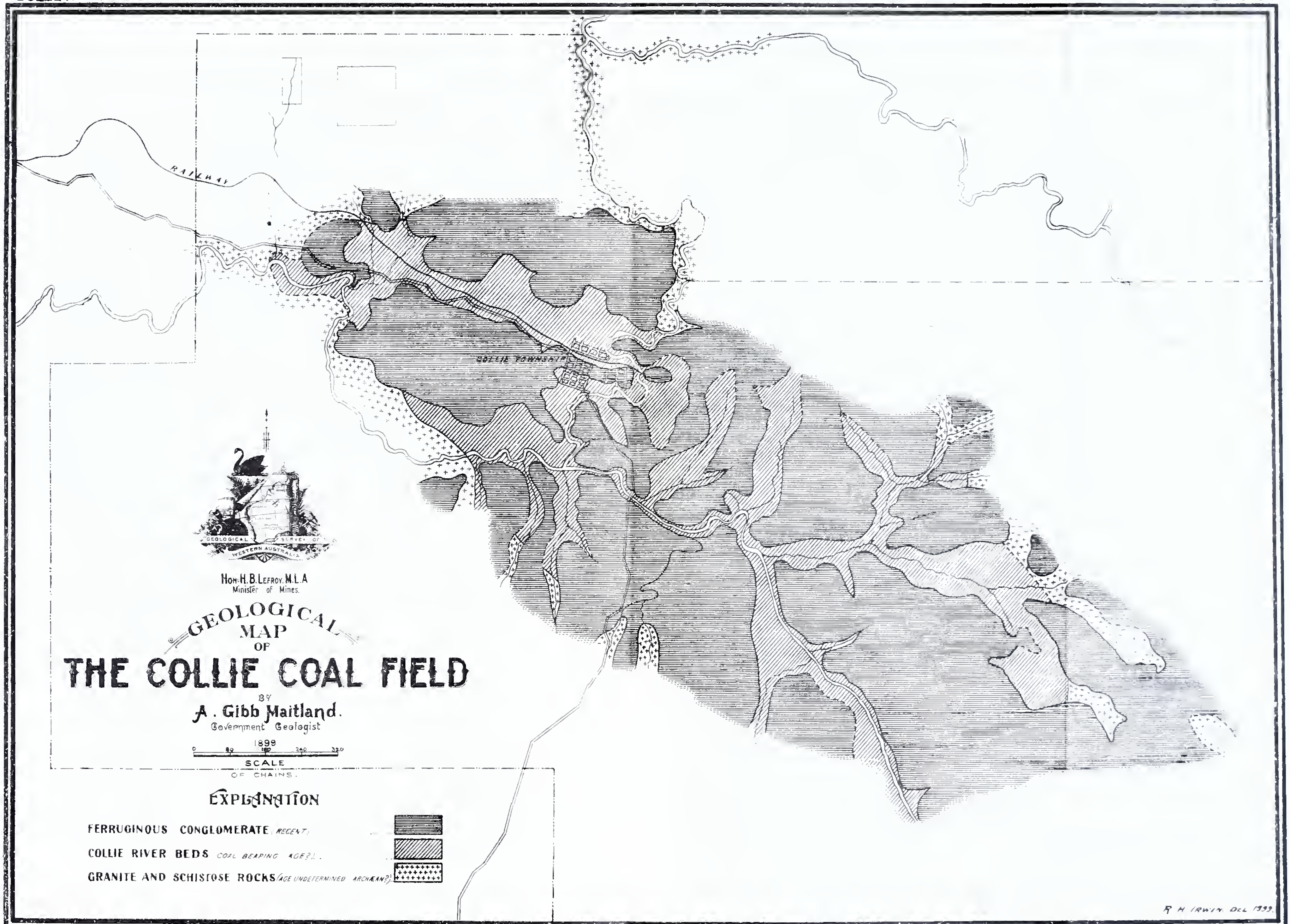
MINERALS.	ESTIMATED VALUE. £	s.	d.	REMARKS.
Asbestos	1	0	0*	*Customs Records.
Coal	27,712	0	0	
Copper	208,297	10	0*	
Gold	16,446,569	2	8*†	*†Includes the value of the gold coined at the Mint.
Guano	318,488	15	0	
Iron (flux)	8,939	0	0	
Lead	377,820	5	0*‡	‡Includes pig lead.
Limestone (flux) ...	2,833	0	0	
Mica	291	0	0*	
Tin	99,490	0	0*	
Total ...	17,490,446	12	8	

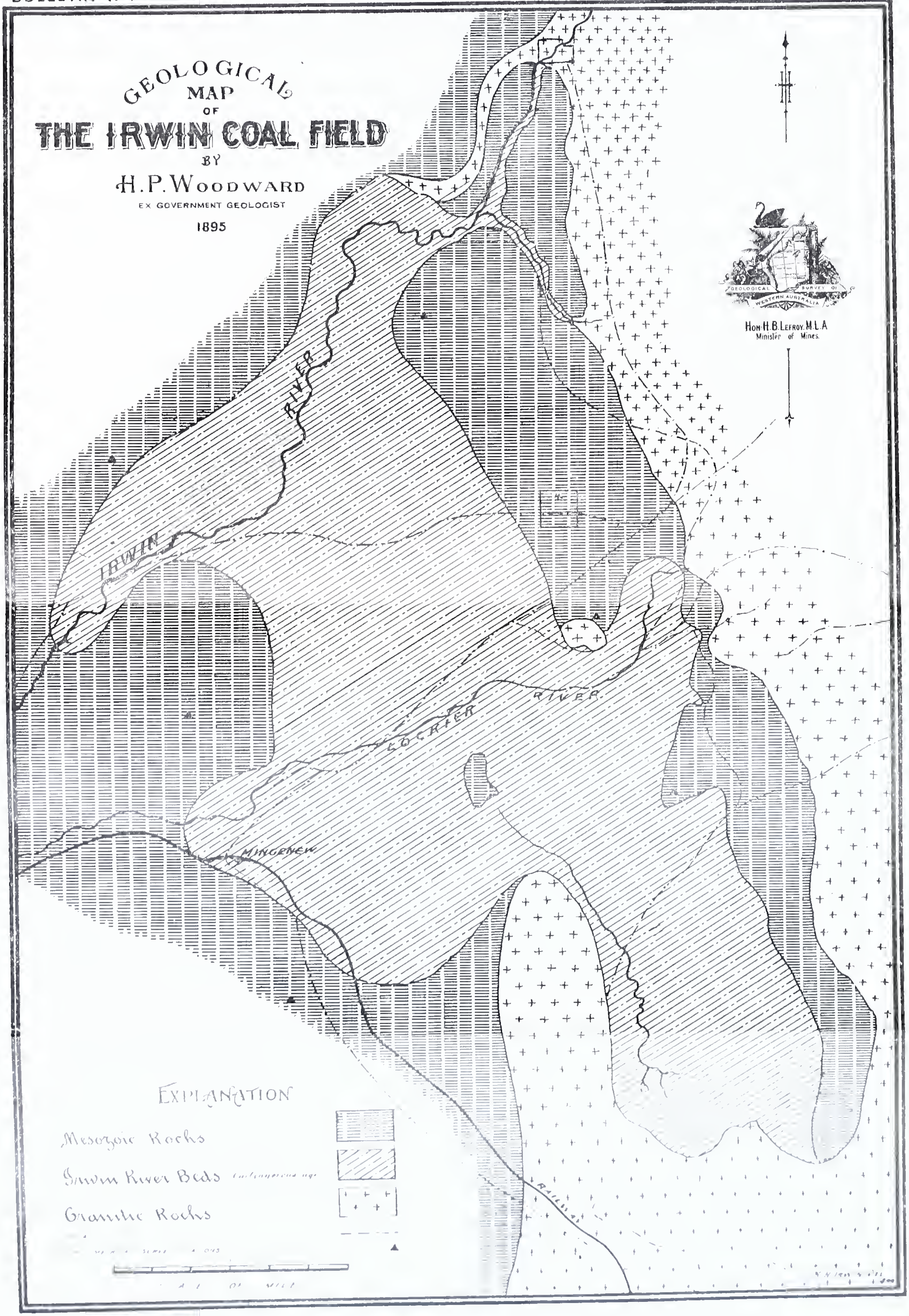
By Authority: Richard Pether, Government Printer, Perth.

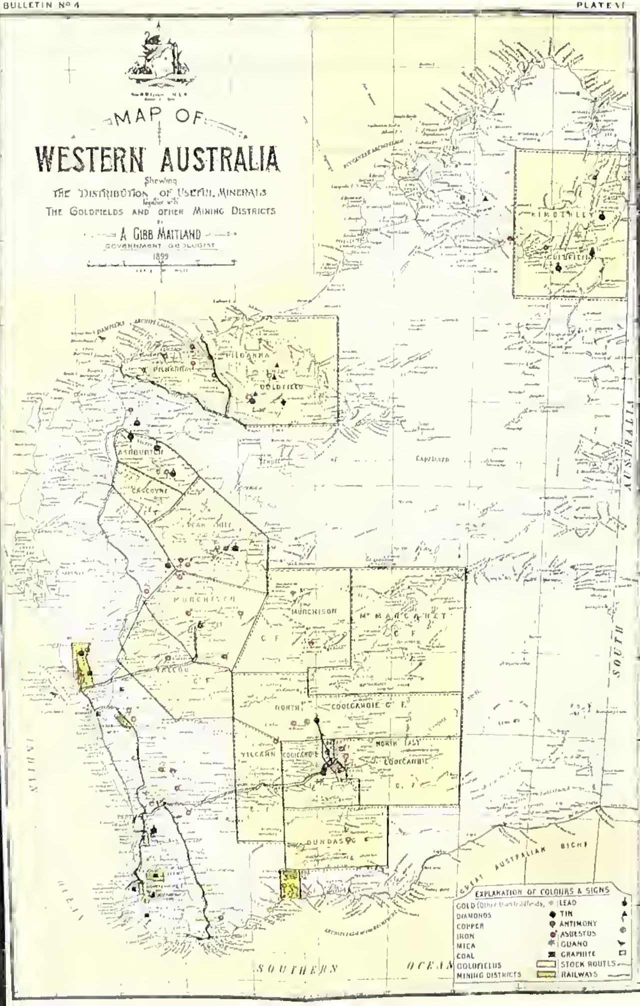

GEOLOGICAL MAP OF COOLGARDIE
TORRINGTON BLATCHFORD AND E. L. ALLHUSEN
EXPLANATION
Recent Superficial Deposits
Ironstone Gravel
Diorite
Granite
Porphyrite
Schists
Felsite Dykes
COOLGARDIE TOWNSHIP
Government Geologist


GEOLOGICAL
MAP
OF
GREENBUSHES
TINFIELD
A. Gibb Maitland.
GREENBUSHES
TOWNSITE
Alluvial Deposits
Older Alluvial Deposits
Conglomerate
Crystalline Rocks
Scale of Chains


GEOLOGICAL MAP
NORTHAMPTON
Scale of Chains
EXPLANATION
ALLUVIUM
SANDSTONE & CONGLOMERATE
DIORITE DYKES
TOWNSHIP
NORTHAMPTON


RAILWAY
COLLIE TOWNSHIP
GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
Hon. H. B. Lefroy, M.L.A
Minister of Mines.
GEOLOGICAL MAP OF
THE COLLIE COAL FIELD
BY
A. Gibb Maitland.
Government Geologist
1899
0 80 160 240 320
SCALE
OF CHAINS.
EXPLANATION
FERRUGINOUS CONGLOMERATE (RECENT)
COLLIE RIVER BEDS (COAL BEARING AGE?).
GRANITE AND SCHISTOSE ROCKS (AGE UNDETERMINED ARCHÆAN?)
R. H. IRWIN. DEC 1899.


GEOLOGICAL MAP OF THE IRWIN COAL FIELD
BY H. P. WOODWARD
EX GOVERNMENT GEOLOGIST
1895
GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
HON. H. B. LEFROY, M.L.A.
Minister of Mines.
IRWIN RIVER
LOCKIER RIVER
MINGENEW
RAILWAY
EXPLANATION
Mesozoic Rocks
Irwin River Beds
Granite Rocks


MAP OF
WESTERN AUSTRALIA
Showing
THE DISTRIBUTION OF USEFUL MINERALS
together with
THE GOLDFIELDS AND OTHER MINING DISTRICTS
by
A. GIBB MAITLAND
GOVERNMENT GEOLOGIST
1899
KIMBERLEY
GOLDFIELD
PILBARRA
GOLDFIELD
ASHBURTON
GASCOYNE
MURCHISON
MURCHISON
G F
Mt MARGARET
G F
NORTH
COOLGARDIE G F
NORTH EAST
COOLGARDIE
G F
YILGARN
COOLGARDIE
DUNDAS G F
GREAT AUSTRALIAN BIGHT
SOUTHERN OCEAN
SOUTH AUSTRALIA
EXPLANATION OF COLOURS & SIGNS
GOLD
DIAMONDS
COPPER
IRON
MICA
COAL
GOLDFIELDS
MINING DISTRICTS
LEAD
TIN
ANTIMONY
ASBESTOS
GUANO
GRAPHITE
STOCK ROUTES
RAILWAYS